U.S. Army Research Institute for the Behavioral and Social Sciences

Research Report 1834

Reduced Exposure Firing with the Land Warrior System

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The Land Warrior (LW) system provides the Soldier a new combat capability – the ability to conduct surveillance and to fire from a reduced exposure posture. The day capability is achieved with the daylight video sight; the night capability with the thermal weapon sight. An experiment was conducted to determine the relative lethality of this capability versus standard direct fire techniques. The LW v1.0 system was used. Soldiers who participated in the experiment represented a cross-section of military occupational specialties. Data were obtained on probability of hit, round dispersion, target acquisition, and Soldier exposure to the enemy. Over all the experimental conditions, marksmanship accuracy was reduced somewhat (18% decrease), but Soldier exposure was decreased by 75% compared to direct fire positions and the absolute amount of exposure was small. A training plan was developed that identified the required skills and incorporated the training lessons learned on techniques and firing exercises that facilitate skill acquisition.

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FOREWORD

The U.S. Army's Land Warrior (LW) program is an acquisition program to provide ground Soldiers with enhanced warfighting and digital capabilities. The Infantry Forces Research Unit of the U.S. Army Research Institute for the Behavioral and Social Sciences has supported the LW program since 1998. This support has included evaluations and assessments of training programs given to Soldiers prior to tests and experimentation, training impact analyses, and research on media to train prerequisite skills required by the LW system. The research documented in this report examined the reduced exposure firing capability of the system. It was the first systematic examination of this technique of fire, which is a unique capability of the LW system. This research supports work package "Future Force Warrior Training" (215). It also supports the Science and Technology Objective "Training Small Unit Leaders and Teams."

The experiment was supported by the TRADOC Systems Manager – Soldier (TSM-S), G3 US Army Infantry School (USAIS), and the Project Manager-LW (PM-LW). The experiment involved a cross-section of Soldiers who used both reduced exposure firing and standard direct fire techniques during day and night. Lethality was reduced somewhat with this technique of fire (18%), yet the firer's exposure to the enemy was reduced by 75%. Use of a Location of Misses and Hits (LOMAH) range provided critical data on bullet location and enhanced the ability to train Soldiers. The critical skills required with this technique of fire were identified, and a training plan developed to support acquisition of these skills.

The results were briefed to the PM-LW in February 2004, to TSM-S and G3, USAIS in May 2004, and to the Chief Infantry Futures in November 2004. In addition, complete reports on the experiment were provided to PM-LW, TSM-S, and G3, USAIS. The lethality and survivability databases generated from the experiment were provided to the Army Materiel Systems Analysis Activity (AMSAA) for use in future constructive and virtual simulations. Needed improvements to one of the sights used in the experiment were provided to the LW Weapons Integrated Product Team and were used to modify the next version of the sight. The results supported the Analysis of Alternatives for LW Block II. In addition, the findings provide critical information on the lethality that can be achieved by Soldiers using the LW system in reduced exposure firing positions, and on Soldier survivability. They provide information on reduced exposure training procedures and resources. Lastly, the findings provide a basis for developing reduced exposure firing standards.

Michelle Sams

MICHELLE SAMS
Technical Director

Acknowledgement

The reduced exposure firing experiment described in this report was the collective effort of many individuals and many agencies. Without their support, the experiment could not have been conducted and would not have been completed.

The authors wish to thank the other members of the data collection team who worked throughout the four-week period: Rich Wampler (Northrop Grumman Mission Systems), Chris Carstens (Human Research and Engineering Directorate, Ft. Benning), and Ken Evans (ARI, Ft. Benning). MAJ Manauis and Glenn Kohlhase from the Soldier Battle Lab and Mr. John D'Errico from the TRADOC Systems Manager-Soldier at Ft. Benning, GA, provided logistics support throughout. MAJ Manauis also served as the firer for one excursion and coached many of the firers.

Colin Drennen and Bob Sowers from the Project Manager-Land Warrior (PM-LW) Office were on site to troubleshoot and repair the Land Warrior systems. Without their assistance the experiment could not have been completed. Mr. Tom Foster (G3, Directorate of Operations and Training, Infantry School), MAJ Russ Perkins (TRADOC Systems Manager-Soldier) and Mr. Leon Brown (PM-LW) were instrumental in ensuring the experimental plan could be executed with Soldiers, ranges, equipment, and ammunition.

Lastly, the authors extend their appreciation to the Soldiers from the 11th Infantry Regiment and the 29th Infantry Regiment who participated as firers in the experiment. Their enthusiasm did not wane throughout the effort, and their professionalism and interest in the project greatly contributed to its success.

REDUCED EXPOSURE FIRING WITH THE LAND WARRIOR SYSTEM

EXECUTIVE SUMMARY

Research Requirement:

The Land Warrior (LW) system provides the Soldier a new combat capability – the ability to conduct surveillance and to fire from a reduced exposure posture. A Soldier can observe and fire at targets by exposing only a small fraction of his body and his weapon compared to normal, direct view techniques. The reduced exposure firing capability is provided via a computer link from two sights on the weapon, the daylight video sight (DVS) and the thermal weapon sight (TWS), to the Soldier's helmet-mounted display (HMD). This link allows the Soldier to see the image of the target in the HMD, and thereby eliminates the requirement to obtain a direct or "eyes-on" view of the target in order to fire. Prior to the experiment reported here, no systematic investigation of the lethality achieved with reduced exposure fire capability had been conducted, nor had the training requirements for reduced exposure firing been examined empirically. The experiment focused on firing from defensive positions. Insights regarding hasty firing positions were obtained through several excursions.

Procedure:

The experiment compared the reduced exposure firing effects with the DVS during the day to direct view firing effects with the Close Combat Optic. At night, the TWS was used in both the standard direct view mode and the reduced exposure mode. Live-fire test scenarios addressed target acquisition, round dispersion, and probability of hit. Soldiers (n = 17) represented a cross-section of Military Occupational Specialties and varied in their military experience. A within-subjects design was used. Every Soldier fired all scenarios from the direct fire and reduced exposure positions with all appropriate optics. The experiment required four weeks, with the training and testing of each subset of Soldiers requiring three days. Scanning and hasty firing position excursions were conducted with a sample of the Soldiers. The extent to which the Soldier's body was exposed to the enemy was also assessed.

Findings:

The results showed the potential benefits of this technique of fire. Over all conditions, lethality was reduced somewhat with the reduced exposure fire (probability of hit decreased 18%). Round dispersion was slightly greater as well. However, the firer's exposure of his body to the enemy was 75% less than that from a direct fire position and the absolute amount of exposure was small, making the firer less vulnerable to enemy fire. Use of a Location of Misses and Hits (LOMAH) range provided critical data on bullet location and enhanced the ability to train Soldiers. The ability to assess target acquisition was limited because of the restricted sector of fire on the firing range. The critical skills required with this technique of fire were identified. The ability of the Soldier to establish a stable position was critical, with each Soldier's position tailored to his own physique and firing preferences. In addition, a sling was identified as needed for firing from hasty positions. A training plan was developed to support acquisition of the critical skills.

Utilization of Findings:

The results were provided to the TRADOC Systems Manager-Soldier, Project Manager-Land Warrior, and G3 United States Army Infantry School for use in making design decisions regarding the LW system. The lethality and survivability databases generated from the experiment were provided to the Army Materiel Systems Analysis Activity for use in future constructive and virtual simulations. Needed improvements to the DVS were provided to the LW Weapons Integrated Product Team and were used to modify the next version of the sight. In addition, the findings provide critical information on the lethality that can be achieved by Soldiers using the LW system in reduced exposure firing positions, and on Soldier survivability. They provide information on reduced exposure training procedures and resources. Lastly, the findings constitute a basis for developing reduced exposure firing standards.

Future research should build on the current database and knowledge gained in this experiment. The current experiment identified three major areas that need to be examined in more depth. First, there is a need to examine target acquisition proficiency as a function of the size of the sector of fire. The tactical advantage of conducting surveillance when the firer has a very low probability of being detected needs to be thoroughly examined, as scanning from a reduced exposure position may be used more frequently in combat situations than firing at targets. Second, more research is needed on how to train Soldiers to quickly detect and engage targets from various offensive, hasty firing positions. Given that urban combat conditions are commonplace, the importance of determining what is required to train Soldiers in this environment is critical. Third, research is needed on how to train Soldiers to detect, acquire and hit moving targets, from both hasty and defensive reduced exposure positions. This is a higher level of skill than that investigated in the present experiment.

REDUCED EXPOSURE FIRING WITH THE LAND WARRIOR SYSTEM

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Introduction

New weapon systems provide capabilities that must be verified through testing. Integral to this process is training Soldiers on the systems being tested, as typically the capabilities cannot be verified without a Soldier-in-the-loop. The Land Warrior (LW) system provides the Soldier a new combat capability – the ability to conduct surveillance and to fire from a reduced exposure position. A Soldier can observe and fire at targets by exposing only a small fraction of his body and his weapon compared to normal, direct view techniques. The dangers associated with exposing yourself to the enemy in combat are well known. Even snipers can be hit because of accidental exposure, as described by Cox (2004) in the *Army Times*. The reduced exposure firing capability with the LW system is provided via a computer link from two sights on the weapon, the daylight video sight (DVS) and the thermal weapon sight (TWS), to the Soldier's helmet-mounted display (HMD). This link allows the Soldier to see the image of the target in the HMD, and thereby eliminates the requirement to obtain a direct or "eyes-on" view of the target in order to fire. No systematic investigation of the reduced exposure fire capability had been conducted prior to this research.

Reduced exposure firing presents several new challenges to the firer. The Soldier must use different firing positions from those described in FM 3-23.99 (Department of the Army, 2003) for most training and in record fire. Although many reduced exposure firing positions can be used, in general, they are less stable than those used for record fire (foxhole supported, prone unsupported). In addition, target detection must be achieved through the DVS or the TWS display. The DVS has a restricted field of view as compared to what Soldiers typically see with iron sights or the close combat optic (CCO). In fact, the CCO can be fired with both eyes open, thereby providing a very wide field of view. With the TWS, however, the fields of view as displayed in the HMD via indirect view are the same as those seen via the direct view.

Limited data exist on how well Soldiers can scan and hit targets from reduced exposure firing positions. Very preliminary data were obtained during the training period prior to the Joint Contingency Force Advanced Warfighting Experiment (JCF AWE) on the medium TWS (Dyer, Fober, Wampler, Blankenbeckler, Dlubac, & Centric, 2000). Soldiers used LW version 0.6 during the JCF AWE train-up. Because of time limitations, there was no formal training on firing positions prior to the reduced exposure firing. All reduced exposure firing was done with the TWS from defensive foxhole positions, with targets at 50 to 200 meters.

Another limited effort to examine reduced exposure firing was conducted as part of the human factors evaluation of the LW version 1.0 system (Krausman, Boynton, Harper, Ortega, & Wilson, 2004). Reduced exposure firing was conducted with the DVS only, using standing and kneeling positions, and targets at 50 to 300 meters. Only one training trial was conducted prior to the experimental trials.

The research reported here differs from these prior efforts in areas other than training. The reduced exposure trials used the DVS designed for LW version 1.0 and the light TWS, thereby providing data on day and night firing. The Soldier sample was expanded to include Soldiers who did not hold an Infantry military occupational specialty (MOS). The range instrumentation provided precise information on the distance of each round fired (hits and misses) relative to center mass of the target, a more precise measure than the dichotomous hit and miss measures available on most Army ranges. Target acquisition time was assessed. Known distance as well as pop-up target scenarios were used. Marksmanship performance with reduced exposure fire was compared to direct view fire performance.

With respect to survivability from a reduced exposure position, a study by Katz, D'Errico, and Kohlhase (2001) examined the amount of a firer's body and his equipment exposed to the enemy when using current equipment in direct view positions and using LW equipment in reduced exposure positions. Six different firing positions were examined with both sets of equipment. One individual modeled all positions. In addition, Katz et al. determined the probability of the enemy hitting the firer as a function of three enemy weapon/ammunition combinations. Soldier exposure was consistently less from a reduced exposure position, as was the likelihood of the firer being hit by enemy weapons. The current trials also examined Soldier exposure, but with a slightly different measurement technique. In addition, the sample size was larger, although fewer firing positions were examined. There was no calculation of the probability of enemy weapons hitting the firer, as was done in the Katz et al. study.

The reduced exposure firing experiment had several purposes.

- One purpose was to determine the effects of using reduced exposure firing positions with the LW system on lethality, specifically time to acquire targets, the dispersion and location of rounds, and probability of hitting targets. The DVS and the light TWS were used in this mode of firing, for day and night fire conditions respectively. Reduced exposure firing conditions using the DVS and TWS were compared to direct view, exposed ("standard") firing positions.

- A second purpose was to compare the reduced exposure probability of hitting targets to that achieved by firing "blindly" at targets from a reduced exposure position. This was called the unobserved/unaimed fire position, since the firer's head was down and he was unable to see targets – no "eyes on".

- A third purpose was to compare the amount of exposure of the Soldier to the enemy from reduced exposure positions and direct view, exposed firing positions.

- The last purpose was to identify effective means of training Soldiers to use reduced fire techniques with the LW system.

It was expected that Soldiers in a reduced exposure position using the LW system would perform better than when in the unobserved/unaimed position, but not as well as when using the exposed, direct view, aimed fire day and night positions. The experiment determined the magnitude of the differences in marksmanship performance associated with these distinct firing positions, as this had not been investigated previously.

The findings have multiple applications for the Army. They provide critical information on the lethality that can be achieved by Soldiers using the LW system in reduced exposure firing positions, and on Soldier survivability. They provide accuracy and survivability data for use in constructive and virtual simulations. They provide information on reduced exposure training procedures, firing scenarios, training time, and training resources. Lastly, they provide a basis for developing reduced exposure firing standards.

Method

Equipment

Version 1.0 of the LW system was used. All Soldiers fired the M4 carbine with the modular rail assembly. The DVS with LW version 1.0 had two fields of view (FOVs). The wide field of view (WFOV) was 16 degrees vertical and 21 degrees horizontal with unity power (no magnification). The narrow field of view (NFOV) was 4 degrees vertical by 5 degrees horizontal with 4-power magnification. The CCO is a unity power sight with a red-dot reticle. The Soldier can fire with two eyes open. Consequently, there is a wide "natural" field of view because the Soldier can use peripheral vision.

The light TWS has two FOVs. The normal field of view is 15 by 15 degrees with 1.55 power. There is also a digital zoom feature that makes the image twice as large, resulting in a 7.5 by 7.5 degree FOV with 3.10x power.

Experimental Design

The design was a within-subjects design; every Soldier fired every test condition. Soldiers fired both the DVS and TWS from two reduced exposure firing positions: above a barricade and around a barricade. From each LW reduced exposure position and with each sight, they fired four test scenarios (see Table 1 and Test Scenario section).

- A target acquisition scenario
- A known distance (KD) scenario
- A field fire scenario (FF) with single and multiple targets and extended target exposure times
- A field fire scenario (FF) with single and multiple targets and standard target exposure times

To determine the effects of the reduced exposure firing positions, comparisons were made to the following conditions.

- Day firing with DVS reduced exposure was compared to firing the CCO from a direct view, exposed position. All four test scenarios listed above were fired using the CCO.
- Night firing with TWS reduced exposure was compared to the TWS direct view, exposed position; that is, using the TWS to engage targets without the LW system. All four test scenarios were fired using the TWS direct view.
- The last condition was an unobserved/unaimed fire scenario using current equipment. Soldiers fired to hit/suppress targets with <u>no</u> "eyes on" the target (head down, unable to see targets), without exposing themselves to enemy to their front.

The unobserved/unaimed scenario was included as it attempted to replicate how Soldiers must fire from a reduced exposure position with current sights. In contrast, the CCO and the TWS direct view conditions were each "exposed" firing positions, and required direct view, aimed fire. The direct view conditions could be viewed as equivalent to firing from above a barricade position, as Soldiers supported their weapon with sandbags. The direct view firing conditions presented a "best case" scenario as Soldiers are very familiar with these firing positions. They are used in marksmanship qualification and in field exercises.

Table 1
Experimental Conditions: Firing Position-Weapon Sight Combination and Test Scenarios

Firing Positions and Weapon Sight	**Test Scenarios**			
	Scenario A: Target Acquisition Field Fire, 6 single target presentations	**Scenario B: Known Distance** 3 targets presented, # rounds dependent on target distance	**Scenario C: Field Fire w/ Extended Target Exposure Times** Multiple & single target presentations - 22 total	**Scenario D: Field Fire w/ Standard Target Exposure Times** Multiple & single target presentations – 10 total
	Day Fire			
CCO comparison	6 rounds	20 rounds	22 rounds	10 rounds
DVS reduced– above a barricade	6 rounds	20 rounds	22 rounds	10 rounds
DVS reduced– around a barricade.	6 rounds	20 rounds	22 rounds	10 rounds
	Night Fire			
TWS with direct view comparison	6 rounds	20 rounds	22 rounds	10 rounds
TWS reduced – above a barricade	6 rounds	20 rounds	22 rounds	10 rounds
TWS reduced – around a barricade.	6 rounds	20 rounds	22 rounds	10 rounds
No sights	**Day Fire** Unobserved/unaimed fire scenario - 10 rounds			

Note. Every Soldier fired every scenario (A through D) from each firing position and sight combination, plus the unobserved/unaimed fire scenario.

Test Scenarios

The target sequences for each of the four test scenarios are in Table A-1 (Appendix A). Data collection forms used for the test scenarios are in Appendix B. For both day and night firing, the scenarios were fired for all positions in the order shown --- Scenario A, B, C, and then D. Thus, for example, during the day, Scenario A was fired from all three positions prior to firing Scenario B. The scenarios were ordered by difficulty, with Scenario A being the easiest, and Scenario D, the most difficult. Test scenarios were fired only after Soldiers had received training in reduced exposure firing techniques.

The target acquisition scenario (Scenario A) provided measures of the time to acquire targets and the percentage of targets detected at each distance. This condition was designed to assess how difficult it was for Soldiers to physically scan the sector of fire with their weapon from a reduced exposure position and then detect targets with the field of view provided by the DVS and TWS. Soldiers were told they were to obtain a *good* sight picture and then fire. It was not critical that Soldiers hit the target, but that they obtain a good sight picture before firing. Because Soldiers were told their primary task was to detect and acquire targets versus hitting targets, results from this scenario was not used to determine probability of hit. Data controllers recorded whether a round was fired, and the time each round was fired. Even though target acquisition times could have been obtained in Scenarios C and D, due to the special data collection procedures required, time data were not obtained in these scenarios. All targets were single exposures and were exposed for 10 seconds. The 300m-target was presented first, then the 175m, followed by the 75m. This cycle was repeated once, for a total of 6 target presentations. Six target exposures were determined to be enough to provide an index of target acquisition times with the limited sector of fire (1 to 4 degrees) from the firing points on the firing range.

The primary purpose of the known distance (KD) firing (Scenario B) was to obtain an index of the dispersion and location of rounds from center of mass of the target, when target acquisition time was essentially unlimited, thereby eliminating target acquisition as a factor in shooting. With the KD scenario, targets at each distance remained up until the Soldier had fired the required number of rounds. Soldiers acquired targets and fired when they had a good sight picture. At 75m, the Soldier fired 5 rounds; at 175m, 10 rounds; and at 300m, 5 rounds. Probability of hit was also of interest with the KD firing.

The two field fire test scenarios, with targets at 75, 175, and 300m, were used to obtain probability of hit data, as well as round location and dispersion measures. Scenario C was a modified field fire, 22-target scenario with single and multiple (double) exposures. The scenario was modified for longer exposure times -- 10 seconds for single targets, and 20 seconds for double exposures. There were four (4) single exposures and nine (9) double exposures. The 75m and 300m targets were exposed as a single target once; the 175m-target was a single target twice.

Scenario D was a standard 10-target, field fire table (Basic Rifle Marksmanship Period 8) with single and double exposures. Exposure times were shorter than Scenario C, ranging from 5 to 11 seconds, with exposure times increasing as a function of range and double exposures. There were two (2) single exposures and four (4) double exposures. In Scenario D, the 300m-target was always paired with a 75m or 175m target. The standard exposure scenario (Scenario D) had fewer targets in order to minimize firer fatigue.

The unobserved/unaimed fire scenario required the Soldier to fire 10 rounds from a reduced exposure position without using the LW system. The Soldier could select to fire from a foxhole or prone position. In either position, he had no vision of his sector of fire. He was only told that there were enemy to his front; that he was to engage the enemy and to do the best he could to hit the enemy. Soldiers were not told the distance to the enemy target. Each Soldier determined his rate of fire. The 175m-target was presented and remained up until all 10 rounds had been fired. This scenario was executed during the day only.

Reduced Exposure Firing Positions

Two reduced exposure firing positions were used: above a barricade and around a barricade. These were "stable," "defensive" type positions as opposed to assault positions. In each case, the Soldier was to use the image displayed in the LW helmet mounted display (HMD) as the means of acquiring and engaging targets. The criterion for the "above a barricade" position was that the Soldier's head was below his weapon, thus forcing him to shoot "above a barricade." The criterion for the "around a barricade" position was that the weapon was to the right or left of the Soldier and "around a barricade." Soldiers used sandbags or boxes as the barricade. In all cases, the barricade was of sufficient size to prevent exposure of the Soldier's head and other parts of the body to potential enemy. In contrast, with direct view positions, the Soldier's head was not exposed. How extent to which his arms and hands were exposed depended on technique used by each Soldier. However, in the above the barricade position, typically none of the Soldier's body was exposed (see Figure 6.). In the around a barricade position, a small part of firing arm may have been exposed (see Figure 6).

In both reduced exposure conditions, Soldiers could fire from a prone position or from a foxhole. Soldiers selected the position with which they were more comfortable and which provided them weapon stability. Pictures of typical positions used by Soldiers are in the Results section of this report. Practice fire was used to help each Soldier determine the position that worked best for him.

When using the CCO and TWS in the direct view mode, the Soldier fired as he normally would during field fire or record fire scenarios. Again, he was allowed to choose his position, prone or foxhole. When zeroing the CCO, DVS and TWS, reduced exposure positions were not used.

Excursions

Firing excursions were conducted with a limited number of Soldiers. A dry-fire scanning excursion was executed with the CCO and the DVS. The other excursion involved live fire from various assault positions, with and without a sling. None of the excursions was planned, but each was identified during experiment as having the potential to provide valuable, additional information on reduced exposure firing. Details on the design of these excursions are in the Results section.

Soldiers

The experimental design specified five Soldiers for each of four weeks, for a total of 20 Soldiers. Due to unexpected Soldier turbulence and unavailability, only 15 Soldiers had complete test data for the day test firing with the CCO and the DVS, and 17 for the night test firing with the TWS. Data are reported on only the Soldiers who had complete test data for the day and/or the night fire. As stated previously, the design was a repeated measures design, with each Soldier firing each scenario (15 Soldiers firing all day and night scenarios, 2 firing only the night scenarios).

Of the 17 Soldiers, 9 were marksmanship instructors from the 29th Infantry Regiment at Ft. Benning, GA. The other 8 were assigned to the 11th Infantry Regiment and were awaiting a Forces Command assignment. In addition, 47% (n = 8) were NCOs, 41% (n = 7) were privates or specialists, and 11% (n = 2) were Officer Candidate School (OCS) students just completing the course. Although most (70%, n = 12) were Infantry; 30% (n = 5) were not Infantry. Non-Infantry specialty areas were Health Care (medic), Air Defense, Field Artillery, Food Service, and Band (saxophonist).

Soldiers (16 of the 17) reported their latest marksmanship record fire score. Their mean rifle marksmanship record fire score was 33.4 hits out of a possible 40 hits, with 44% (n = 7) Expert, 31% (n = 5) Sharpshooter, and 25% (n = 4) Rifleman. All the Infantrymen, except the OCS candidate, had prior experience with the CCO; the other Soldiers had not fired the CCO. Only one Soldier had prior experience with the TWS, as he was a primary instructor for TWS developmental and operational tests. Four other NCOs had experience with the Bradley Integrated Sight Unit (a thermal sight). No Soldier had experience with the DVS.

Four (24%) of the 17 Soldiers were left-eye dominant and left-handed. All used their left eye when firing. Two fired left-handed throughout the experiment. One started firing reduced exposure using his right hand, then switched to his left. One used his right hand for reduced exposure firing throughout. All other Soldiers (76%) used their right eye and right hand. Three required some type of corrective lens for poor eyesight.

There was considerable diversity in military experience of the Soldiers. However, in general, the sample as a whole could be considered above average in terms of marksmanship background and record fire scores.

Procedures

Firing Range and Range Instrumentation

All training and testing was conducted on a location of misses and hits (LOMAH) range, configured for field fire scenarios. Targets were at 75, 175, and 300 meters only. E-silhouettes were at 175 and 300m; F-silhouette at 75m. Only five (5) of the 32 lanes on the range were used. Of these five lanes, every other lane was used for all scenarios, resulting in a maximum of three Soldiers shooting simultaneously. For safety purposes, Soldiers never fired from adjacent lanes. For TWS firing, thermal blankets were placed on the targets.

The LOMAH system provided unique data collection capabilities. In addition, to target hit and miss data, the exact location of each round from center mass of the target was provided, for both hits and misses. This location was given in X and Y Cartesian coordinates (fractions of a meter) from the target's center of mass. In addition, the sequence in which each bullet was fired for a given firing table was recorded. These data allowed determination of round dispersion, location, and distance from center of mass of the target. The LOMAH system also had the capability to assess whether weapons were zeroed at 75, 175, or 300 meters. More information on the output from the LOMAH system is provided under the criterion measures section.

Only rounds within a certain area surrounding the target were detected by the LOMAH system. Specifically, rounds up 2.5 meters above the target were detected, and rounds that were 1.5 meters on either side of the target were detected. Rounds that hit the dirt before arriving at the target were not detected.

A central computer controlled all LOMAH range functions. The LOMAH system included a shot sensor and the firing point equipment (FPE). The FPE presented a graphical display of round locations, and whether the target was hit or missed. In addition, the data controller on the lane entered the Soldier identification code via the external keypad on the FPE. Figure 1 shows the LOMAH setup for the experiment.

Sequence of Events

Instruction and training on reduced exposure positions and the DVS started on the first day. TWS instruction and training began on the second day. On the first day, Soldiers practiced assuming different reduced exposure positions, and how to operate the LW system as it related to reduced exposure firing.

For each of the weapon sights, DVS and TWS, the sequence of major events was as follows:

- boresight and zero (this also included the CCO)
- practice fire from reduced exposure positions with the DVS and TWS
- test scenarios (these included firing from direct view conditions with the DVS and TWS, and the unobserved/unaimed fire scenario)

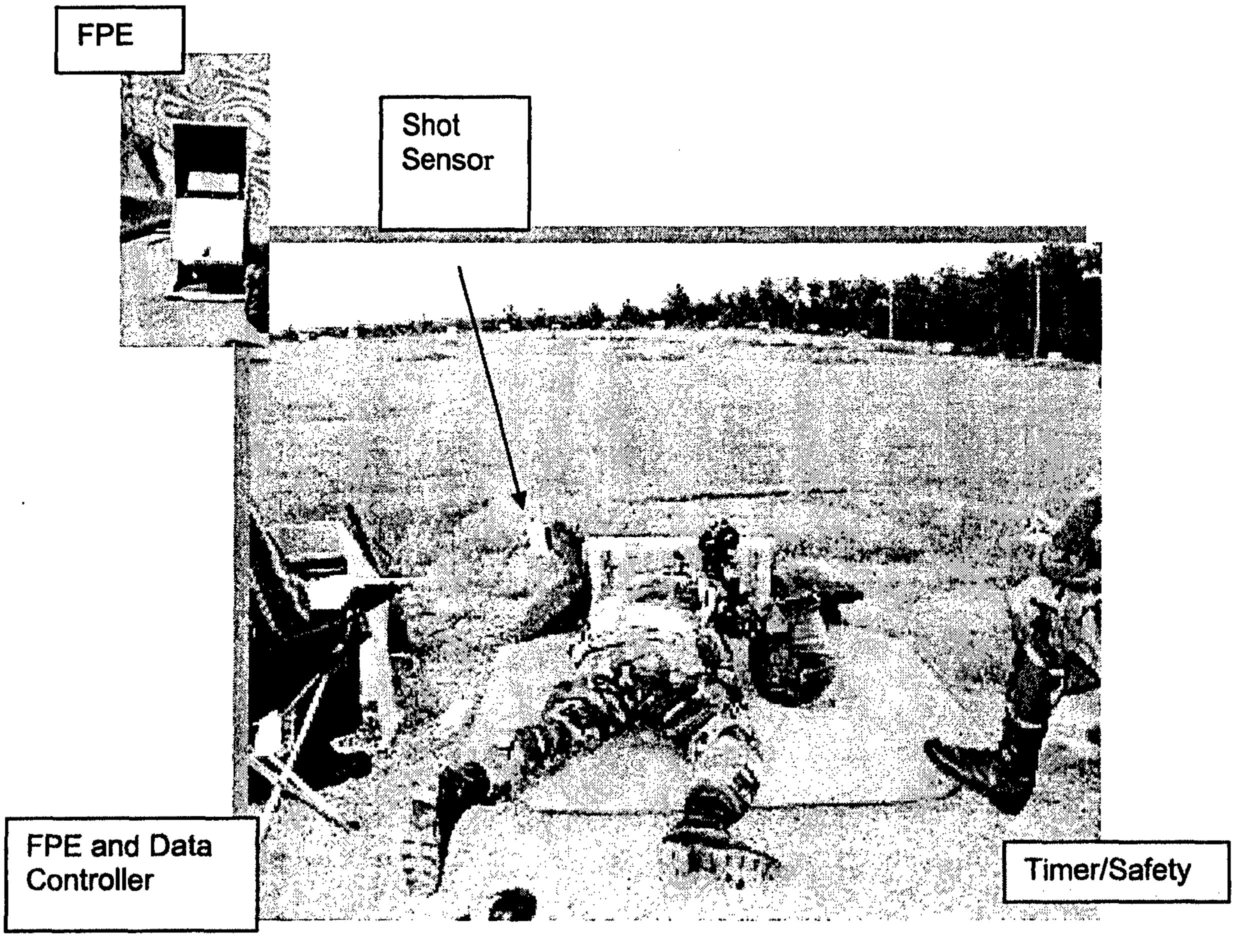


Figure 1. Data controller team and firing set-up.

The zero settings on all sights were confirmed on each subsequent day of firing. For the DVS, the training and firing were executed over three days. The TWS training and firing were executed over two days. A scanning excursion was added to the schedule for Week 3, and an excursion on sling/non sling assault position firing was added to the schedule in Weeks 2 and 4. The detailed weekly schedule is presented in Appendix C.

Boresighting and Zeroing Procedures

Boresighting and zeroing sequence. Soldiers fired the CCO and DVS on all three days, but fired the TWS on only the second and third day. They zeroed the CCO and DVS on the first day of the experiment, and zeroed the TWS on the second day. They confirmed zero on each sight on each of the subsequent days of firing. Thus they confirmed their CCO and DVS zeroes on the second and third days, and confirmed their TWS zero on the third day.

Policies were established to reduce problems associated with confirmation of zero. Sights were not removed from a Soldier's weapon unless required by the experimental design (e.g., CCO removed in order to mount the TWS), or to replace a malfunctioning sight. The DVS did not interfere with the other sights and was not removed, except for malfunctions. Each Soldier used the same M4 carbine throughout. Similarly, he used the specific sights assigned to him throughout. Thus when each Soldier confirmed zero he did not "start from scratch."

Some modifications were made to the data collection forms and boresighting procedures during the first week of the experiment. Boresighting did not occur systematically for any sight during the first week of the experiment. During the first week, the Soldiers zeroed at 175m and used the LOMAH feedback to make all sight adjustments. Boresighting prior to zeroing began systematically with the TWS on the second day of the second week. The boresighting/zeroing data collection forms evolved over the first week, expanding from a single page that covered all three sights to a single page for each sight. The final form, implemented on the second day of the second week, is in Appendix D. The form provided for recording boresight elevation and windage settings, cumulative time to boresight, a running tally of changes to windage and elevation settings during zeroing, the final reticle settings, cumulative time to zero/confirm zero, and number of rounds to zero.

To boresight, each M4 carbine was mounted on a bench rest. A bore light was inserted into the muzzle end of the barrel. Data controllers used a boresight target with aim points for the CCO, DVS, and TWS.

Zeroing with LOMAH. The LOMAH system allows a Soldier to zero his weapon without walking down range. Soldiers zeroed and confirmed zero at 175m. The LOMAH system establishes a "zero area (circle)" appropriate for the target distance. The zero area is based on the trajectory and dispersion of the round. At 175m, the sensitive zero area is 28cm (11 inches) in diameter, as compared to the 4cm circle on the 25m zero target.[1] This area is centered chest high on the target, as 175m is the approximate high point in the round's trajectory.

Current 25m zero procedures are based on three-round shot groups. The LOMAH scoring software is consistent with this procedure. After each three-round shot group, the LOMAH system displays the location of the rounds on the FPE screen and indicates if the Soldier is zeroed, i.e., whether all three rounds are within the zero-sensitive area for the target distance. If not zeroed, the LOMAH system indicates the required windage and elevation changes necessary to zero the sight. This information is presented only when the Soldier has a tight shot group.

[1] With LOMAH, the 4-cm zero used for zeroing at 25m is projected to 75, 175, and 300m. The location of the sensitive zero area is based on the trajectory of the round, and assumes the Soldier aims at center mass of the target. At 75m, the sensitive zero area is a 5-in diameter circle. At 300m, the sensitive zero area is a 19-in diameter circle.

The information on sight adjustments from the LOMAH system is tailored to a weapon-sight combination. For the M4 carbine/M16 rifle, it is based on "iron sight" adjustments. However, these "iron sight" adjustments did not correspond to the appropriate adjustments for the CCO, DVS, and TWS. The required adjustments for each of these sights at 175m were determined. These adjustments were then computed as a function of the iron sight adjustments, so all sight adjustment guidelines were based on the iron sight information presented on the FPE. Data controllers used these revised zero adjustment guidelines to assist Soldiers during the zeroing of each sight, per the handout presented in Table 2.

Table 2
Data Controller Handout for Converting the LOMAH FPE Zero Guidance for M4 Iron Sights to the CCO, DVS, and TWS

	L/R Windage	**U/D Elevation**
CCO	Use FPE	Double or 3x the FPE
DVS WFOV	Divide FPE by 5 (five) & Go in opposite Direction	Divide FPE by 2 (two) & Go in Opposite Direction
DVS NFOV	Use FPE & Go in Opposite Direction	Double or 3x the FPE & Go in Opposite Direction
TWS Normal	Divide FPE by 2 (two) or 3 (three)	Use FPE

Note. Zero in the TWS normal FOV also results in a zero in the zoom mode.

Table 2 shows that the version of the DVS used in the experiment required the data controller to reverse the direction of movement for windage and elevation adjustments from that shown on the FPE screen. This is because with iron sight, CCO, and TWS adjustments, sight or reticle changes move the rounds to the point of aim. If the rounds are low, the required sight or reticle adjustment is "up." With the DVS in LW version 1.0, just the opposite is the case. Reticle adjustments move the reticle to the round location. Thus if the rounds are low, the required reticle adjustment is "down."

One of five outcomes was possible after each shot group. These outcomes are cited below with the corresponding data controller procedures.

- If all shots in the shot group were within the zero-sensitive area, thereby meeting the zero criterion as indicated on the FPE screen, the Soldier had zeroed the sight. The zero reticle setting was recorded for the DVS and TWS.
- If the shot group was not within the zero-sensitive area, but all three shots were detected by the LOMAH system and were within a 28cm diameter circle, adjustment recommendations appeared on the FPE screen. Based on the zero adjustment handout (Table 2), data controllers determined the adjustments, gave them to the Soldier, and observed while the

Soldier adjusted the sight/reticle. The data controller recorded the Soldier's adjustments on the boresight and zero data sheet, recorded that three rounds had been fired, and then instructed the Soldier to shoot another three-shot group at the target. This procedure continued until the sight was zeroed.

- If the shot group was not within a 28cm diameter circle (e.g., rounds were scattered widely), the data controller used his best judgment regarding the next shot group – whether to adjust the sight/reticle or to have the Soldier shoot again.
- If the shot group was not detected by the LOMAH system, the data controller used his best judgment regarding zero procedures (e.g., shoot again, change point of aim). This outcome was infrequent.
- On occasion, Soldiers had difficulty zeroing. For example, when a Soldier could repeatedly place two shots into the zero-sensitive circle, but fail to place a third round in the same circle, the data controllers had to decide whether to continue firing. When the data controllers considered a zero was achieved even when the LOMAH system did not, it was because two of the three rounds were in the zero area, the third round was in close proximity, and it appeared that further firing or adjustments would not improve the shot group.

Firing position for zeroing. Soldiers selected their preferred firing position, prone or foxhole, for zeroing. They were told to fire from their preferred position – the position that gave them the most confidence in achieving a good zero. Reduced exposure positions were not used for zeroing.

CCO and DVS boresighting and Initial zero procedures. The CCO and DVS were boresighted and/or zeroed in the same block of time each day. Each Soldier determined the CCO rail position based on eye relief and personal preference. After attaching the CCO, the Soldiers attached the DVS, donned the LW system, connected the DVS cable, and logged on to the LW system. On Day 1, Soldiers practiced using the HMD to view objects through the DVS. They also viewed the DVS reticle adjustment screen, practiced making reticle adjustments with the Soldier Control Unit (SCU "mouse"), and practiced toggling between the DVS WFOV and NFOV. See Figure 2 for an "idealized" graphic of the DVS reticle adjustment screen.

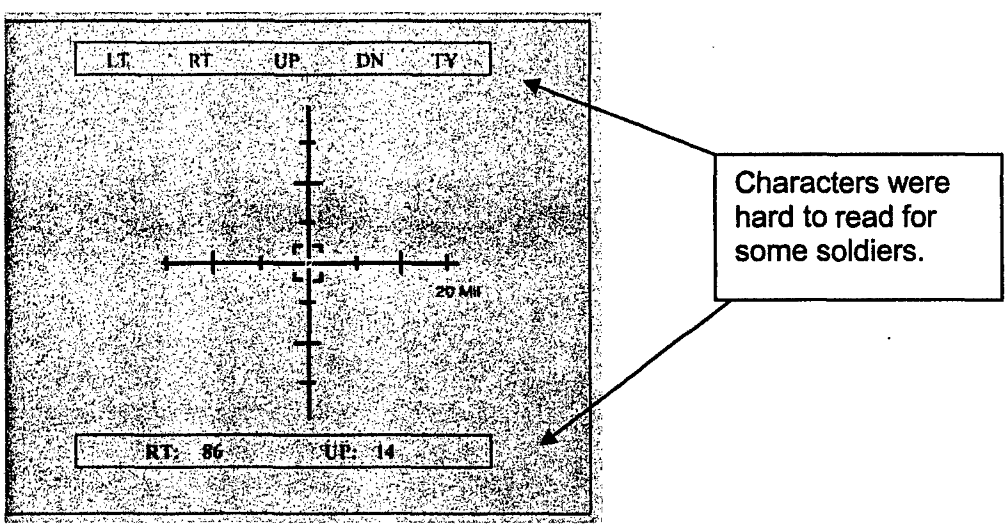


Figure 2. DVS WFOV reticle (Source: Omega Training Group; enhanced image of reticle).

The DVS must be boresighted and zeroed in each FOV to shoot accurately in each. The intent was to have Soldiers zero and fire in both fields of view. However, Soldiers quickly recognized that it was much easier to see the 175m and 300m targets with the DVS in the NFOV. As a result, Soldiers boresighted, zeroed, and fired the DVS in the NFOV throughout the experiment. After boresighting, each Soldier zeroed the CCO and DVS using the 175m on the LOMAH range according to the procedures described previously.

TWS boresighting and initial zero procedures. Soldiers had to remove the CCO from the weapon in order to attach the TWS. Soldiers did not don the LW system during TWS boresighting. Instead, they used the TWS in the direct view, meaning that they placed their dominant eye against the eyecup to view the boresight target instead of viewing the thermal image through the HMD.

Because of time constraints, TWS zeroing, using direct view, was executed late in the afternoon, rather than at night. Zeroing was at 175m, and a thermal blanket on the 175m-target created a heat signature. Zeroing procedures were the same as for the DVS and CCO. With the TWS, once the Soldier is boresighted or zeroing in the standard FOV, he is also boresighted or zeroed with the electronic zoom.

Confirmation of zero. Before Soldiers fired the CCO and DVS on Days 2 and 3, they confirmed zero at 175m with each sight. Soldiers confirmed zero with the TWS on Day 3.

Training and Practice Firing

On Day 1 of each week, Soldiers were briefed of the purpose of the experiment. Information on their marksmanship background was obtained.

Equipment and reduced exposure positions. For the LW and reduced exposure training, there was one primary instructor, and one or two members from the research team who assisted with practical exercises as needed. On Day 1, Soldiers were taught only the functions necessary for operating the LW system during reduced exposure firing. This included donning the LW system, logging-on, using the SCU and the weapon user interface device (WUID) to work with the graphical user interface (e.g., toggle between the map, the DVS, and TWS images). Soldiers were also taught how to adjust the DVS reticle, and to switch between the DVS WFOV and NFOV.

This was followed by experimentation and practice in assuming reduced exposure positions on the firing lanes. The above and around a barricade positions were demonstrated. Soldiers were presented the criteria for each position: head not exposed, reduce exposure of other parts of the body to a minimum (e.g., arms), weapon above the head for firing above a barricade, weapon to either side of the body for firing around a barricade, with only part of the firing arm exposed.

Field expedient materials (sandbags, mortar crates) were available for constructing a barricade, as well as a vertical shield made from rubberized canvas (sign covers used on the firing range) suspended between two poles. Soldiers were allowed to experiment with different positions until they found ones that provided the needed stability for firing. The more experienced Soldiers typically determined these positions on their own. The less experienced Soldiers often needed assistance from the instructor or a member of the research team, who pointed out factors they needed to consider in establishing a stable firing position. Figure 3 illustrates some of the firing positions Soldiers tried out during train-up, but did not use during the practice and test scenarios.

The firing positions used were unique to each Soldier, dependent upon his physique, his preferred position for firing (prone or foxhole), and whether he used sandbags or boxes as a barricade. On Day 1, the training time was also used to give the Soldiers experience scanning with the DVS. The total time to instruct the Soldiers on the LW system and to practice assuming reduced exposure positions ranged from 3 to 4 hours, depending on the number of Soldiers and their experience.

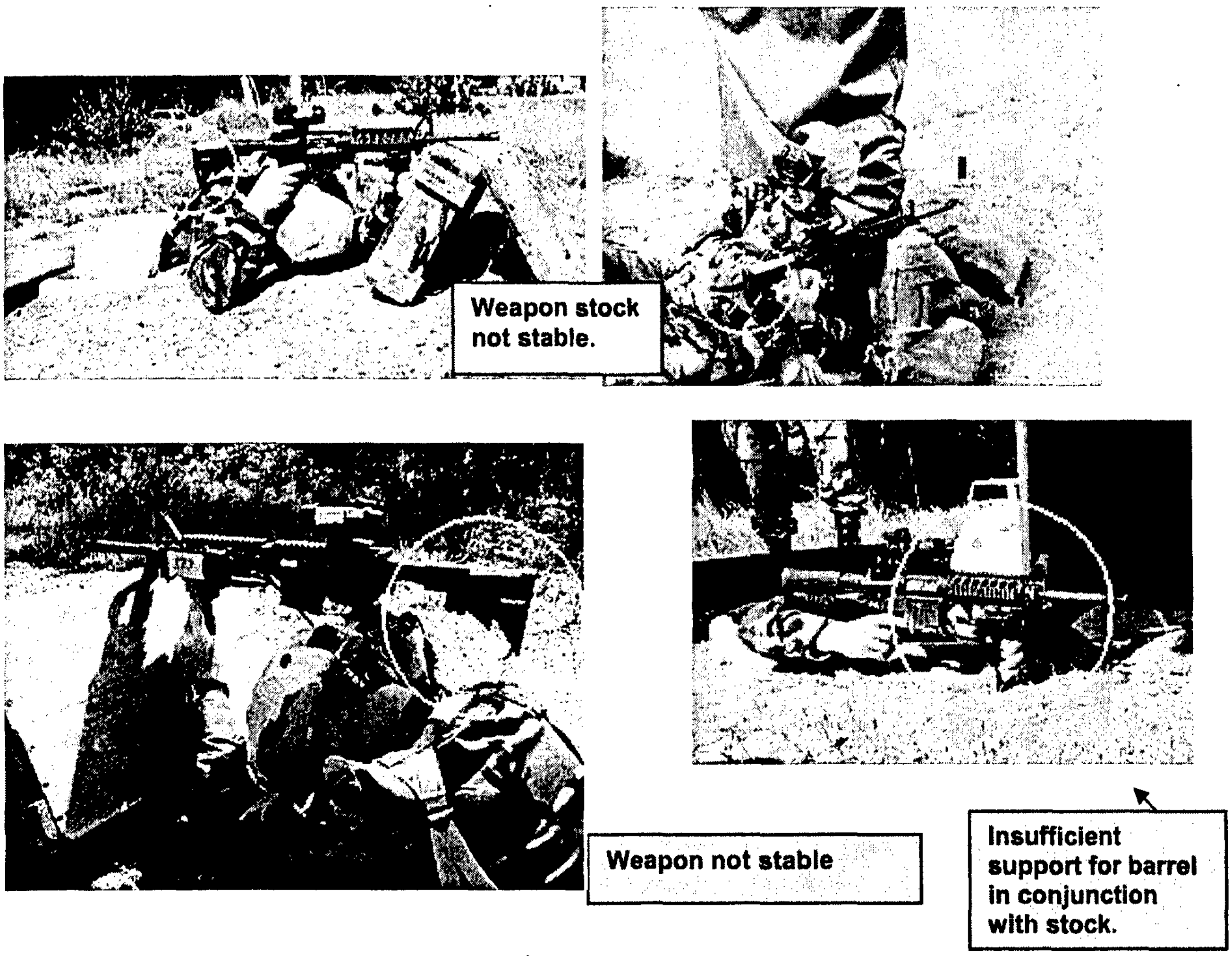


Figure 3. Reduced exposure firing positions tried in train-up, but not used during the practice exercises and the live-fire scenarios.

On Day 2, Soldiers began the afternoon with TWS training. Initial training involved using the TWS independently of the weapon. They received instructions on the TWS controls. They worked with the controls while viewing objects on the range and the range targets, which had thermal blankets. This allowed Soldiers to practice changing the contrast and brightness settings, adjusting the focus control, switching between the standard and zoom fields of view, placing the TWS into emergency mode, and using the toggle to adjust the reticle. They also practiced assuming reduced exposure positions with the TWS. This training session took about half the time (1.5 hours) of that on Day 1 with the DVS, because the Soldiers were already experienced with operating the LW system, and had fired from reduced exposure positions with the DVS. No new instruction occurred on Day 3.

Practice fire scenarios. During reduced exposure practice, Soldiers fired three scenarios. These scenarios were not executed with the CCO or the TWS in the direct view mode. The three practice scenarios were all conducted after all Soldiers had zeroed the DVS or the TWS, and before all the test scenarios. These scenarios are shown in Table 3 and Table A-2. The scenarios were executed in the order shown in Table 3: Dry-fire, KD, and then field fire. Data collection forms for the practice scenarios are in Appendix B.

Table 3
Practice Scenarios by Reduced Exposure Condition

Firing Condition and Sight	**Dry-Fire**	**Live-Fire**	
	Field Fire w/ Extended Exposure Single targets	**Known Distance**	**Field Fire w/ Extended Exposure,** Single & multiple targets
		Day Fire	
DVS reduced – above a barricade	18 targets	20 rounds	10 rounds
DVS reduced - around a barricade	18 targets	20 rounds	10 rounds
		Night Fire	
TWS reduced – above a barricade	Not executed	20 rounds	10 rounds
TWS reduced - around a barricade	18 targets	20 rounds	10 rounds

Note. The TWS dry-fire practice scenario was conducted only from the around a barricade position because of time constraints at night.

In the dry-fire scenario, the Soldier had to indicate when he had acquired the target. The data controller then recorded the elapsed time. Targets not acquired were indicated on the data collection sheet. The KD scenario was identical to that in the test scenarios. Soldiers were told to ensure they had a good sight picture and a stable position before firing. The field fire scenario was their exposure to firing at single and multiple targets. Data collection procedures were the same as those used during the test scenarios. The data controllers provided feedback on target acquisition and target hits during the practice scenarios. Soldiers were observed to modify their reduced exposure positions during the practice scenarios, as this was their initial exposure to target acquisition and to firing from reduced exposure positions.

Ammunition

During practice and test firing, each soldier fired 352 rounds from reduced exposure positions, and 116 rounds from the direct view comparison positions. Additional rounds were used for zeroing and confirming zero.

Criterion Measures

The criterion measures were:

- Time to acquire a target. The data controllers recorded time during the Field Fire scenarios. However, acquisition time was formally assessed only during the target acquisition scenario. Time to acquire was not a requirement for the KD scenario.

- Target hit/miss outcomes as assessed by the LOMAH system. Four outcomes were possible with each round fired:
    - Target was hit by the round
    - Round was within the LOMAH detection area but missed the target
    - Round was outside the LOMAH detection area
    - Soldier did not fire

- The X and Y deviation (in meters) from center mass of the target for all rounds detected by the LOMAH system. These data were used to determine radial miss distance from center mass of the target, as well as to examine, graphically, the location of rounds on and near the target.

All scenario data were recorded by distance to the target. Other descriptive data were obtained, to include whether the Soldier fired from the prone or a foxhole, and problems in firing. The same measures were recorded for the live-fire practice scenarios. The DVS and TWS boresight reticle settings were recorded after the initial boresight. All zero settings were recorded, as well as the time to zero and rounds to zero.

Graphical output at each firing point. On each lane, the FPE provided a graphical display of the location of each round as well as a score reflecting whether the round hit or missed the target. The outcome of each round, in the order in which it was fired, was displayed. The data controller monitored the FPE display. Soldiers could look at the FPE to see the shot results for practice scenarios, and zeroing. However, they typically did not look at the screen on the FPE after each shot during practice, as the data controller gave feedback regarding hits and misses, and the location of the round relative to center mass (e.g., high and right). However, Soldiers were encouraged to look at the FPE screen when they were having difficulty in hitting targets during the KD practice fire scenario, as they could pause during the firing of this scenario. In addition, they frequently used the FPE screen during zeroing. Soldiers were not allowed to look at the FPE screen during the test scenarios.

Graphical output from the central computer. A hard copy of each Soldier's results for each live-fire scenario was available via the central LOMAH computer. An example of this type of output for the KD scenario is in Figure 4. The 75, 175, and 300m targets are shown separately. Each shot within the LOMAH detection zone is displayed in the corresponding "target display panels." A shot is labeled by a "+" sign and a number indicating the shot order [$+_1$ is the first shot; $+_5$ is the fifth shot]. The position of the "+" sign indicates the location of the shot relative to the target. The outcome of each shot, by shot sequence (No. 1 through n), is shown on the right side of each target display under the "Hit" column. The outcome codes are as follows: a "1" indicates a hit, a "0" indicates a miss within the LOMAH detection area, and an "(M)" indicates a miss outside the LOMAH detection area. There is no "+" sign for a shot not detected by LOMAH, only the outcome code of "(M)", which is presented next to the appropriate shot sequence number.

The number sequence reflects shots, regardless of outcome. For example, if the 4th bullet at the 75m target was not detected by LOMAH, the 5th bullet retained its shot sequence number of 5. It was not given the number 4. In addition, for the field fire scenarios, there was a single listing of all the shots fired. The distance to the target (75m, 175m, or 300m) for each round outside the LOMAH detection zone [each marked as "(M)"] was derived from the pre-determined test scenario.

Lastly, at the top of the LOMAH printout was other identifying information: the firing lane, scenario, and Firer-ID. For the reduced exposure trials, the Firer-ID was a four-digit code that combined a two-digit code for the scenario with a two-digit code assigned to each Soldier.

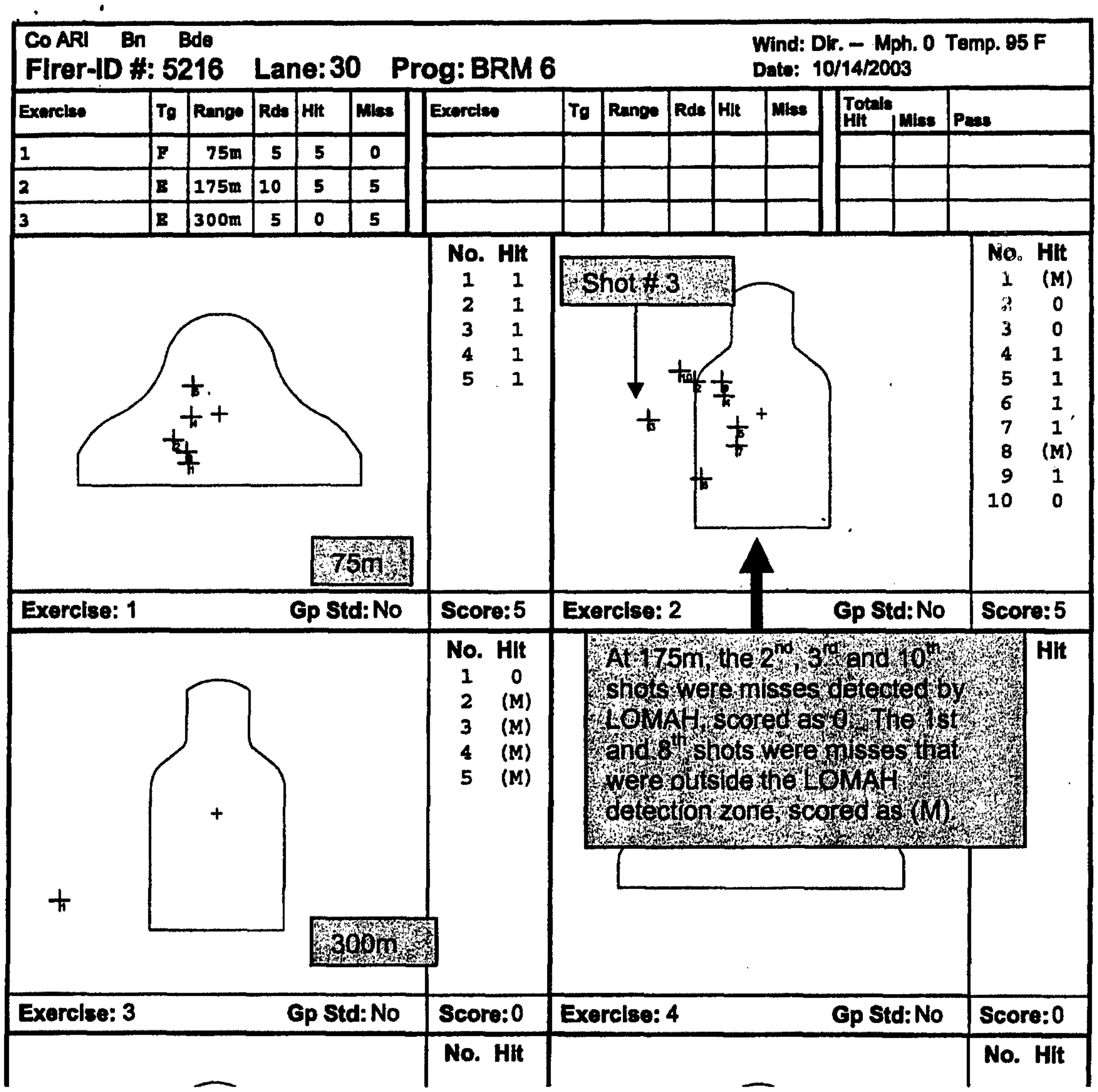


Figure 4. Example of LOMAH graphical output for the KD scenario.

Spreadsheet data. The LOMAH system also provided an Excel-type spreadsheet with information on each round fired. The fields used for the reduced exposure firing were: time of shot, date, FirerID, shot order, hit/miss (1 = hit, 0 miss whether in or outside the LOMAH detection area).

The LOMAH spreadsheet did not provide all the required variables. The required additional variables and associated data were generated from the LOMAH graphical printout (see Figure 4) and the data controller forms. These variables were added to the LOMAH spreadsheet to generate the complete database for the statistical analyses. Two examples of variables that were added are mentioned here. The field fire scenarios did not present the distance to the target, only the shot order and shot outcome. The distance to the target for each round in the field fire scenarios was obtained from the graphical printout in conjunction with the prescribed scenario. Information on "no fires" was only available from the data controller forms. The final spreadsheet used in the statistical analyses contained the fields as shown in Appendix E, Table E-1.

Data Controllers and Support Personnel

Two data controllers were assigned to each lane, for a maximum of six (6) controllers on the firing lanes. The data controllers were responsible for ensuring the FPE was working and the shot sensor was placed appropriately, entering the correct four (4) digit scenario-FirerID into the FPE, safety, troubleshooting when problems occurred with the LW system, completing the data collection forms, ensuring the Soldier was in a reduced exposure position, etc. How this workload was distributed between the two individuals on each lane varied with each pair of controllers.

In addition, a member of the research team ran the LOMAH system from the range tower. Another member assisted with troubleshooting, ammunition, range details, etc. as required. An officer from the Soldier Battle Lab at Ft. Benning assisted the Soldiers in assuming good firing positions.

Measuring Soldier Exposure to the Enemy

Another phase of the reduced exposure trials was to quantify the extent to which a firer's exposure to a hypothetical enemy was decreased through using the LW system in a reduced exposure posture. Measurements were taken of the amount of firer's body and weapon, in square inches, that was exposed to a hypothetical enemy to his front. A limitation of this procedure was that it did not assess other possible exposures to the enemy. However, measurements were taken for the direct view and reduced exposure positions when firing from both above a barricade and around a barricade. Figure 5 illustrates how these measures were taken. The technique involved adjustable poles that conformed to the outline of the Soldier's body and equipment that were exposed to a hypothetical enemy directly to his front. This outline was then traced onto paper in order to calculate the square inches of exposure. Five Soldiers participated in this measurement process.[2]

[2] These Soldier measurement procedures were developed by a staff member from the TRADOC Systems Manager-Soldier office at Ft. Benning. This individual also took the measurements.

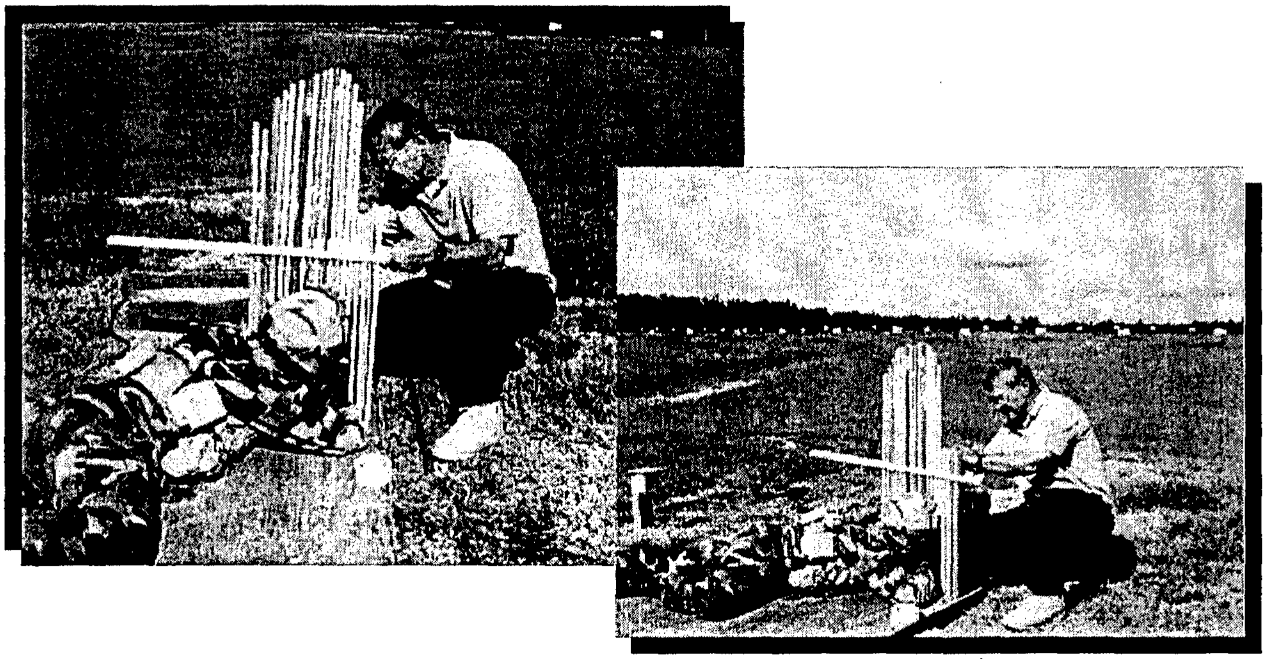


Figure 5. Measurement technique for determining amount of Soldier exposure.

Results

At the beginning of each major section of the results, a summary of findings is presented in a text box. Following each summary are the detailed results and statistical analyses.

Table 4 summarizes the firing data available for each Soldier ($n = 21$). Soldier turbulence in week 2, where four Soldiers were available for only one day, resulted in incomplete data. Except for the unobserved/unaided fire scenario, their data were not used. These data explain why the number of Soldiers was not the same for all analyses.

Firing Positions and Field of View

Soldiers used the DVS NFOV because the WFOV image was not clear.
The majority (85%) used the TWS zoom, either alone or in conjunction with the normal FOV.

Soldiers were about evenly split between preferring a prone versus foxhole position, and they tended to be consistent in their preference across the sight-position combinations.

Table 4
Firing Data by Soldier

Week	Soldiers	Days in Trials	Sights Used	Practice Scenarios Fired	Test Scenarios Fired	Zero Data Available
1	Three privates; one specialist	Days 1-3	ALL	ALL	ALL	Complete data on rounds. Missing some time data on CCO & DVS.
2	Two OCS candidates	Days 1-3	ALL	ALL	ALL	ALL
2	Three privates[a]	Day 1	CCO, DVS	DVS	Unaimed fire scenario only	Day 1 on CCO & DVS
2	Two privates	Days 2-3	TWS	TWS	TWS only	ALL on TWS
2	One private[b]	Day 2	TWS	TWS	1 TWS scenario	Day 2 on TWS
3	Five NCOs	Days 1-3	ALL	ALL[c]	ALL[c]	ALL
4	Three NCOs; one private	Days 1-3	ALL	ALL	ALL	ALL

[a] Only the unobserved/unaimed fire scenario data from these three soldiers were used in the analyses.
[b] None of the data from this Soldier was used in the analyses.
[c] One NCO did not fire the DVS practice scenarios, the CCO/DVS acquire and KD test scenarios, and the unobserved/unaimed fire scenario. He was unable to see the DVS zero screen clearly until Day 3.

Field of View

As mentioned previously, Soldiers used the NFOV on the DVS for the KD and field fire scenarios, because targets were not clearly visible in the WFOV. With regard to the TWS, Soldiers could use the standard field of view or the electronic zoom capability. Based on the Soldiers' verbal reports to the data collectors over all the test exercises 7 of the 14 Soldiers used zoom, two used the normal FOV, and 5 used zoom and the normal FOV.[3]

Firing Positions

The firing positions were classified as prone or foxhole for both the above and around a barricade reduced exposure conditions. Variations did occur in these basic positions, that is, some Soldiers fired over and around a sandbag barricade, some fired around a box-type barricade, some fully extended the collapsible stock on the M4, others collapsed it, etc.

For the day firing, a major finding was that for both the CCO and DVS, 67% of the Soldiers (10 of 15) were consistent in their basic position. Four fired from a prone position, regardless of whether it was CCO exposed or DVS reduced exposure posture. The other six fired from a foxhole position. Results by each sight are in Table 5.

During night firing, Soldiers were also consistent in their basic firing position, with 67% (13 of 17) using the same position across the TWS direct and reduced exposure conditions. Four fired from a prone position; nine from a foxhole position. Night results are also in Table 5.

[3] No data were available on TWS FOV for 3 Soldiers.

Table 5
Firing Positions used with Each Sight

Sight and Condition					
CCO		DVS Above		DVS Around	
Prone Foxhole Prone & Foxhole	5 of 15 9 of 15 1 of 15	Prone Foxhole Prone & Foxhole	8 of 15 6 of 15 1 of 15	Prone Foxhole Prone & Foxhole Fetal	6 of 15 7 of 15 1 of 15 1 of 15
TWS Direct		TWS Above		TWS Around	
Prone Foxhole Prone & Foxhole	5 of 17 1 of 17 1 of 17	Prone Foxhole	8 of 17 9 of 17	Prone Foxhole Fetal	7 of 17 9 of 17 1 of 17

Of the eight NCOs, seven preferred the foxhole position for the TWS, and five preferred it for the CCO and DVS. The four left-handed Soldiers varied in the use of their left hand when using reduced exposure techniques. One Soldier found that he use his right hand with the weapon in his right shoulder. One tried to fire right-handed, but could not achieve a stable position and switched to his left hand with weapon in the left shoulder. The others fired left-handed throughout.

Photos of the firing positions used during the test scenarios are in Figures 6, 7, and 8. They depict both right-handed and left-handed Soldiers, use of sandbags and mortar crates, and day and night fire.

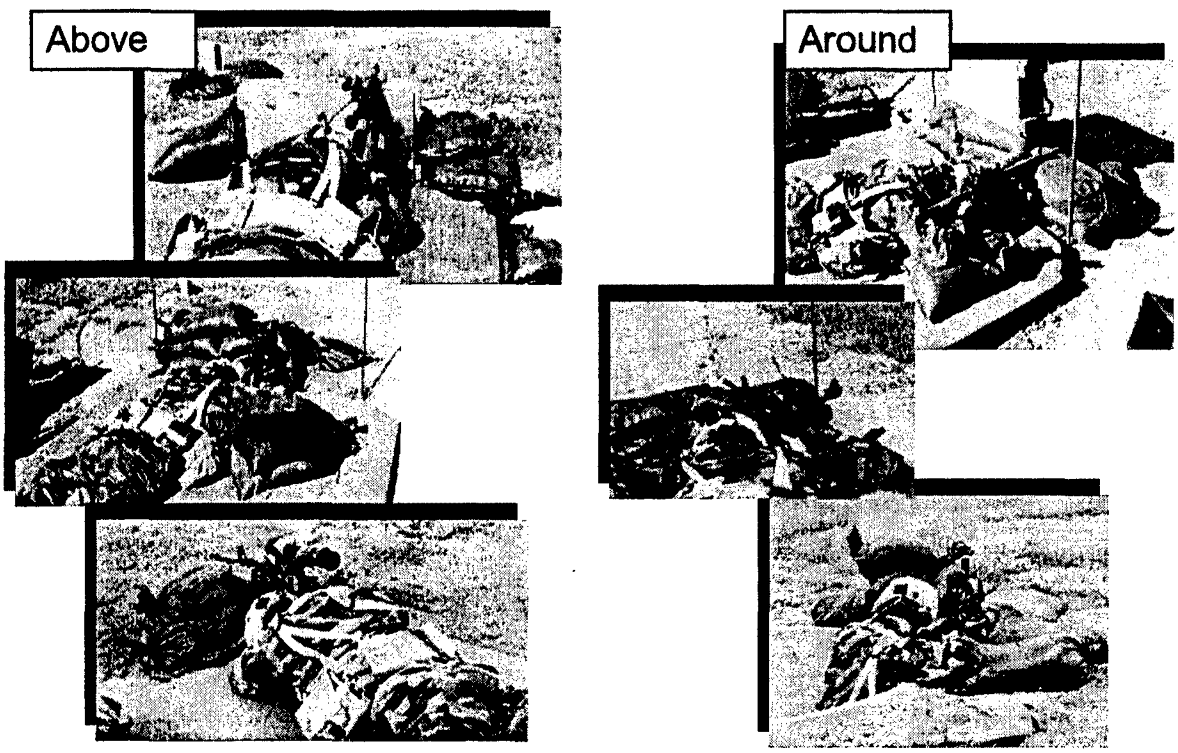


Figure 6. Illustrations of above and around a barricade reduced exposure firing positions.

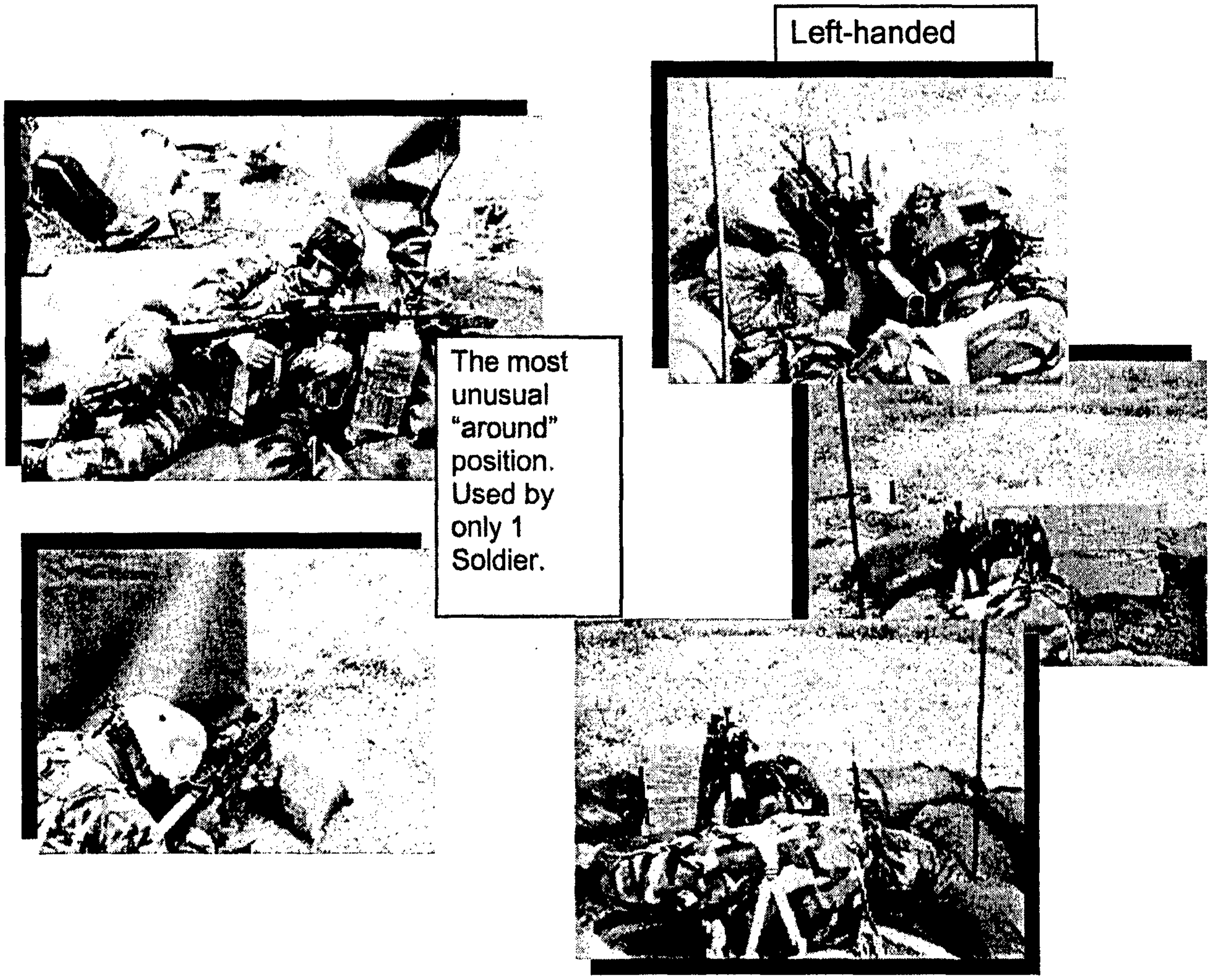


Figure 7. Additional examples of reduced exposure firing positions.

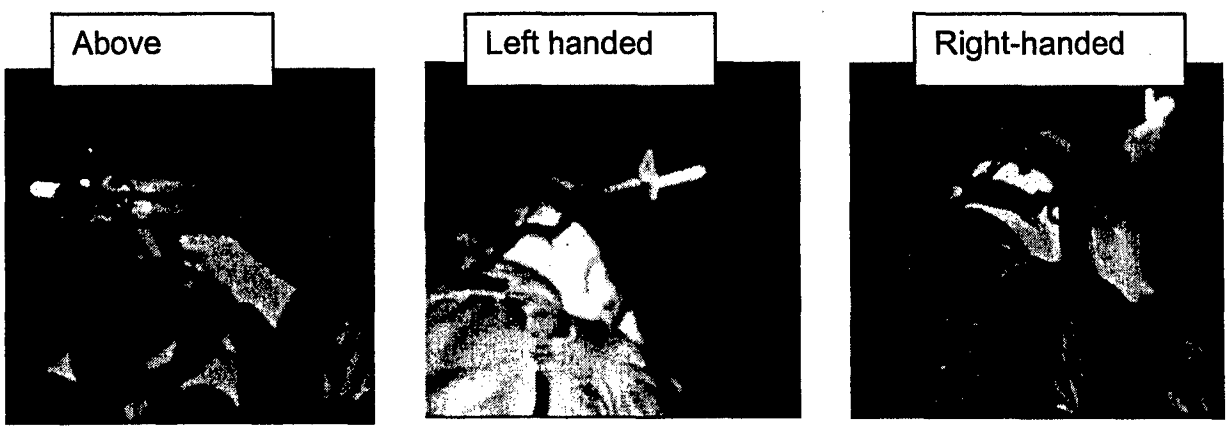


Figure 8. Night firing with the TWS (thermal camera images).

Zeroing

> *There were no significant differences among the sights on rounds to zero. For each sight, the rounds required to zero initially were significantly greater than the number of rounds required during zero confirmation.*
>
> *Time to zero was significantly faster during zero confirmation. The times required to zero and to confirm zero with the DVS were significantly longer than the times for the CCO and TWS, being two to three times as long.*

Statistical comparisons were made on two criteria: rounds to zero and time (minutes) to zero. Soldiers conducted one initial zero with each sight. But they confirmed zero twice with the CCO and the DVS, and once with the TWS. As such, two repeated measures analyses of variance (ANOVAs), with sight and zero iteration being within-subjects factors, were conducted on each dependent variable. The first analysis compared all three sights across the two zero iterations (the initial zero and the first confirm zero). The second analysis compared only the CCO and DVS across the three zero iterations (initial zero, first confirm zero, and second confirm zero).

Only Soldiers who had data on each criterion for all zero iterations were used in the repeated measures analysis. Fifteen (15) Soldiers had complete data on rounds to zero. But for time to zero, only eleven (11) Soldiers had complete data. This discrepancy resulted from a change in the zero data controller sheets from the first to the second week and an unexpected overwriting of some spreadsheet files on the LOMAH computer.

Rounds to Zero

Table 6 presents the mean number of rounds to zero for all the sights and for all the zero iterations. Figure 9 is a graph of these means.

For the three sights with two zero iterations analysis, there was a significant effect for zero iteration, with Soldiers taking more rounds for their initial zero than to confirm zero the first time. The mean number of rounds to zero across all three sights was 20.00 (SD = 11.77), and the mean number of rounds to confirm zero the first time was 11.76 (SD = 9.09). There were no significant differences among the sights, nor was there a significant interaction.

For the two sights (CCO and DVS) with three zero iterations analysis, there was also a significant effect for zero iteration, with Soldiers taking more rounds for their initial zero than to confirm zero the first and second time. The mean number of rounds to zero across the two sights (CCO and DVS) was 20.80 (SD = 12.06); the mean number of rounds to confirm zero the first time was 12.33 (SD = 8.63); the mean number or rounds to confirm zero the second time was 11.80 (SD = 8.15). There were no significant differences among the sights, nor was there a significant interaction.

Table 6
Rounds to Zero

Sight	Statistic	Initial Zero	Confirm Zero #1	Confirm Zero #2
CCO	*M*	21.00	11.07	9.20
	SD	12.16	8.62	3.67
	n	15	15	15
DVS	M	20.60	13.60	14.40
	SD	10.75	6.30	10.77
	n	15	15	15
TWS	*M*	18.40	10.60	Only one confirmation of zero for TWS
	SD	11.39	6.09	
	n	15	15	

Note 1. Three sights and two zero iterations ANOVA. Significant effect for iteration only. No effect for sights; no interaction.
Iteration: $F(1, 14) = 14.11$, $p < .002$, partial $\varepsilon^2 = .502$. More rounds to zero than to confirm zero.

Note 2. Two sights and three zero iterations ANOVA. Significant effect for iteration only. No effect for sights; no interaction.
Iteration: $F(2, 28) = 8.53$, $p < .003$, partial $\varepsilon^2 = .379$. More rounds to zero than to confirm zero.

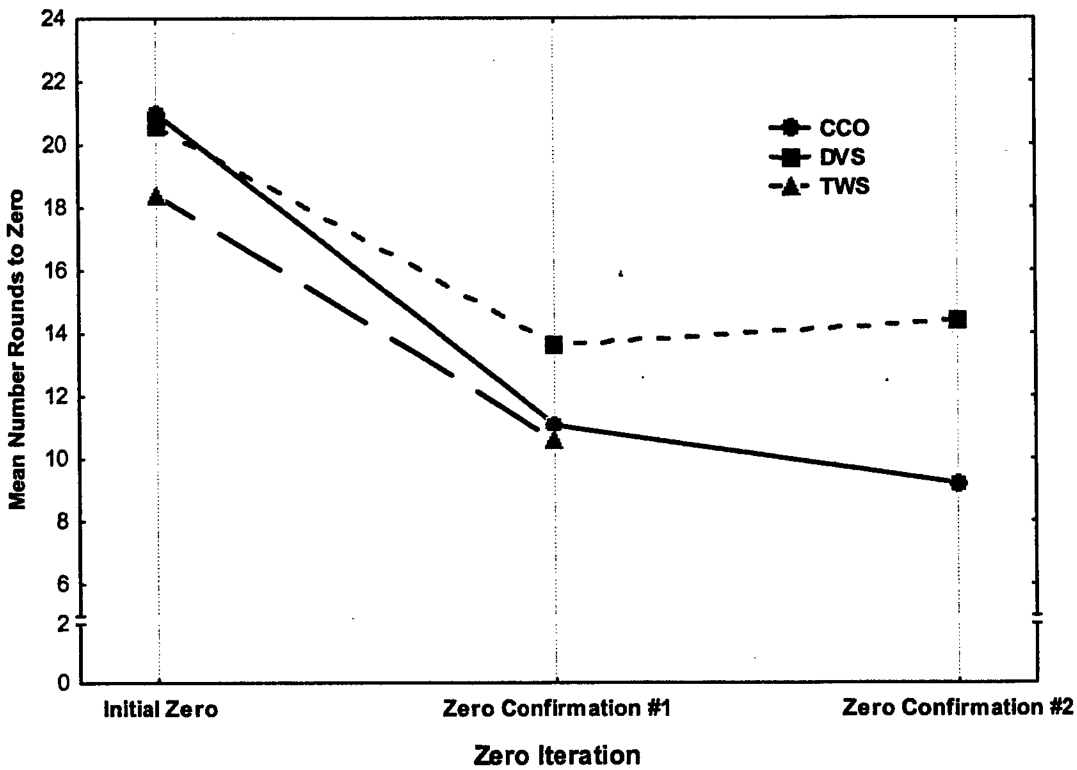


Figure 9. Mean number of rounds to zero for each sight by zero iteration.

Both analyses indicated that Soldiers zeroed in fewer rounds when confirming zero, but that there were no differences among the sights in rounds to zero. The results showed the number of rounds decreased on zero confirmation because the distribution of rounds shifted considerably, particularly for the CCO and the TWS. With the initial zero, there were Soldiers that required a substantial number of rounds over 18, the standard for zeroing. On CCO confirmation, all Soldiers used 18 or fewer rounds. On TWS confirmation, only one Soldier fired more than 18 rounds. However, with DVS confirmation, 3 to 4 Soldiers required more than 18 rounds.

Time to Zero

Table 7 presents the results on the other criterion measure, time (minutes) to zero. The mean times for each sight and zero iteration are illustrated in Figure 10.

Table 7
Time to Zero in Minutes

Sight	Statistic	Initial Zero	Confirm Zero #1	Confirm Zero #2
CCO	*M*	8.89	9.02	4.25
	SD	4.59	8.27	2.33
	n	11	11	11
DVS	*M*	25.64	12.02	9.07
	SD	23.77	10.98	10.89
	n	11	11	11
TWS	*M*	14.07	3.89	Only one confirmation of zero for TWS.
	SD	10.42	3.20	
	n	11	11	

Note 1. Three sights and two zero iterations ANOVA. Significant main effects for sight and iteration. No interaction.
Sight: $F(2, 20) = 6.61$, $p < .022$, partial $\varepsilon^2 = .398$. DVS required more time than CCO and TWS.
Iteration: $F(1, 20) = 5.27$, $p < .045$, partial $\varepsilon^2 = .345$. More time to zero than to confirm zero.

Note 2. Two sights and three zero iterations ANOVA. Significant main effect for sight. Almost significant effects for iteration and the interaction.
Sight: $F(1,10) = 8.96$, $p < .013$, partial $\varepsilon^2 = .473$. DVS required more time than CCO.
Iteration: $F(2, 20) = 4.25$, $p < .052$, partial $\varepsilon^2 = .298$. Less time to confirm zero than to zero initially.
Interaction: $F(2, 20) = 3.62$, $p < .058$, partial $\varepsilon^2 = .266$. Difference in time between DVS and CCO was greatest at the initial zero.

For the three sights with two zero iterations analysis, main effects occurred for both the sight and zero iteration factors. There was no significant interaction. The CCO and TWS required significantly shorter times to zero than the DVS. The mean times for the CCO and TWS were 8.96 minutes (*SD* = 7.22) and 8.98 minutes (*SD* = 8.21) minutes respectively. In contrast, the mean time for the DVS was 18.83 minutes (*SD* = 17.94), twice as long. Confirmation of zero (1st time) was significantly faster than achieving the initial zero. The initial zero required an average of 16.20 minutes (*SD* = 17.43), while the confirmation of zero took 8.31 minutes (*SD* = 11.14), half the time.

For the two sights (CCO and DVS) and three zero iterations analysis, there was a significant difference between sights. The CCO mean time was 7.35 minutes (*SD* = 6.61), while the DVS mean was 15.58 (*SD* = 19.37), twice as long. The main effect for zero iteration was almost significant. However, the interaction between sight and zero iteration was also almost significant and affects the interpretation of the main effect for sight. Although the time to zero the CCO was significantly faster than the time to zero the DVS, this difference was largest when Soldiers initially zeroed each sight. This is illustrated in Figure 10 with the time to initially zero the DVS being three times longer than the time to zero the CCO (25 min vs. 9 min) as compared to 1.6 times longer to confirm zero (10.5 min vs. 6.6 min).

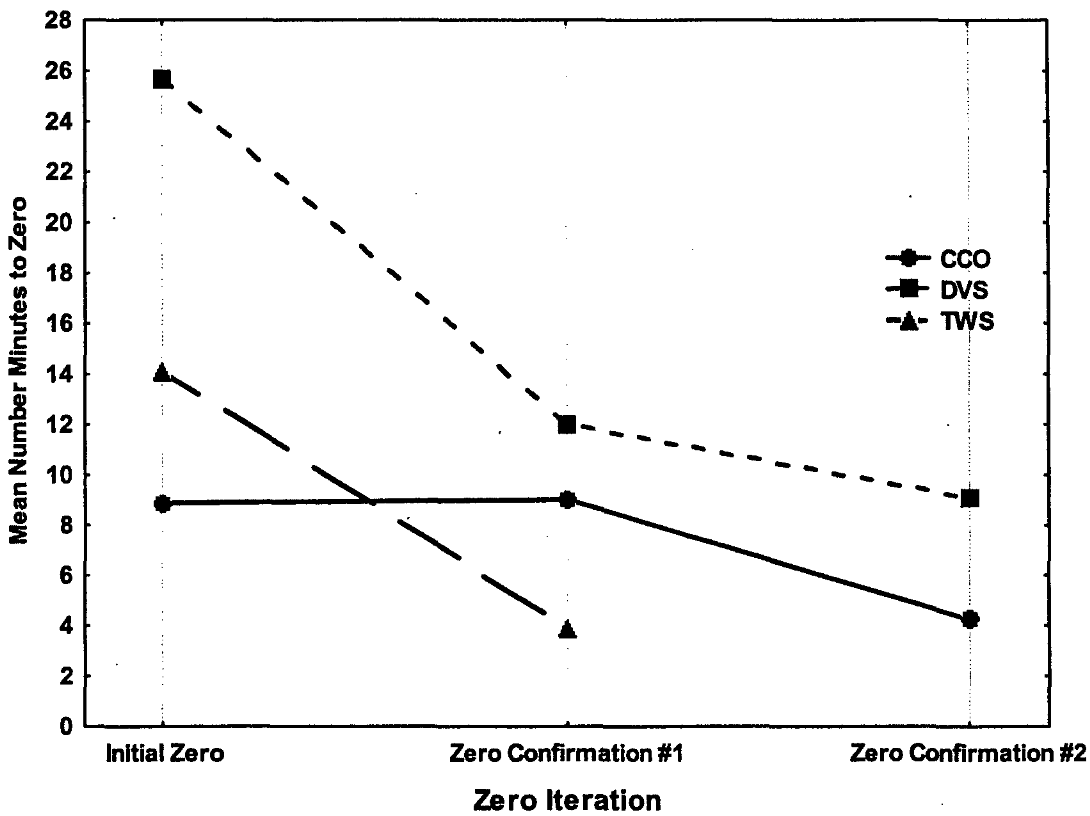


Figure 10. Mean time to zero for each sight and zero iteration.

The long times to zero the DVS reflected two factors. One factor was system unreliability, although it was not possible to determine if the cause was the DVS itself or the Land Warrior v1.0 system. Often the video from the DVS would freeze, the Soldier could not move the cursor, and eventually the Soldier had to reboot his system. The second factor related to the inability of some Soldiers to read the labels on the DVS zero display. Additional time was required to overcome this problem with the DVS.[4]

The fast times for the TWS may reflect, in part, a learning curve for the Soldiers. The initial zero for the TWS occurred after Soldiers had zeroed/confirmed zero with the CCO and the DVS. This prior experience may have helped expedite TWS zeroing and zero confirmation.

[4] Since the experiment was conducted, the reliability problems with the LW system have been resolved. In addition, due primarily to input from the reduced exposure experiment reported here, the labels on the DVS reticle were changed so they were legible, and the reticle adjustment procedures made consistent with other weapon sights.

Also it should be recalled that there were no delays resulting from use of the LW system for TWS zeroing, as Soldiers zeroed the TWS using the direct view mode.

Target Acquisition

Target detection rates were high from all positions and sights – above 90% on the target acquisition and field fire scenarios. Descriptive statistics on times to detect: faster for the direct view conditions during day and night; faster during the day as compared to comparable night conditions, and increased as distance to the target increased. The scan sector was limited, ranging from 1 to 4 degrees.

A scan excursion with the DVS and CCO, covering a large scan sector of 45 degrees. showed a difference in target detection rates. For the CCO, 90% of the targets were detected compared to 35% for the DVS NFOV.

Test Scenarios

The target acquisition scenario was a field fire scenario with two (2) targets at each range; each target was exposed for 10 seconds. The target sequence was 300m, 175m, 75m, 300m, 175m, and 75m. Thus the most distant target was the first to appear.

During the day, Soldiers (n = 14) detected 98% of the targets. From a total of 251 exposures, one failure to detect occurred with the CCO, and three failures occurred with the DVS. All failures to detect during the day were at 300m. At night, Soldiers (n = 17) detected 93% of the targets. From a total of 303 exposures, four failures to detect occurred with the TWS direct view, five failures from the reduced exposure above position, and nine failures from the around position. Most of the failures to detect were at 300m (13 failures); the others were at 175m (5 failures). The target detection percentages by sight-position and distance to the target are in Table 8.

Table 8
Target Detection Percentages in the Acquisition Scenario

Sight-Position	**Distance to Target**		
	75m	175m	300m
CCO	28 of 28 (100%)	28 of 28 (100%)	27 of 28 (97%)
DVS Above	28 of 28 (100%)	28 of 28 (100%)	25 of 27 (93%)
DVS Around	28 of 28 (100%)	28 of 28 (100%)	27 of 28 (97%)
TWS Direct	34 of 34 (100%)	31 of 31 (100%)	30 of 34 (88%)
TWS Above	33 of 33 (100%)	33 of 34 (97%)	31 of 35 (89%)
TWS Around	34 of 34 (100%)	30 of 34 (88%)	29 of 34 (85%)

Note. Any discrepancies in the number of targets cited resulted from a mistake by the Soldier (e.g., firing twice at a target to indicate he detected it). The scenario was not repeated for these Soldiers.

The mean time to detect the targets in the acquisition scenario is shown in Table 9. These descriptive statistics indicate that time to acquire increased as the distance to the target increased. Direct view target acquisition times, both day and night were faster than the reduced exposure times. At each target distance the time to detect during the day was faster than at night.

Table 9
Mean Time (sec) per Soldier to Detect Targets in the Acquisition Scenario

Sight-Position	Distance to Target		
	75m	175m	300m
CCO	1.85	2.73	4.12
DVS Above	2.32	3.36	3.86
DVS Around	2.21	3.57	4.39
TWS Direct	2.18	3.82	4.29
TWS Above	2.79	4.02	5.35
TWS Around	3.03	4.18	4.77

The two other field fire scenarios were examined to determine which targets were never fired at, on the assumption that these targets were not detected. It was of interest to know if additional firing experience and double target exposures impacted target acquisition. Target acquisition times were not recorded for these field fire scenarios. The percentage of targets detected was summarized for all field fire scenarios ranged from 91% to 99%. These results are shown in Table F-1. The detection percentages tended to be higher for the extended exposure time than the standard exposure time. The detection rates by distance to the target in the field fire scenarios are in Table F-2.

Overall the detection rates were quite high. The scan sector was small (1 to 4 degrees between the 300m lane markers). This probably contributed to the high rates of detection, and would not be indicative of detection results that require a substantial shift in the Soldier's firing position as is the case in the Army's record fire scenario, where there are two 50m targets, one to the left of the Soldier's position and one to the right. That scan sector was measured from three firing points on each of two record fire ranges at Ft. Benning. The scan sectors ranged from 10 to 23 degrees, with the most frequent sector being 20 degrees.

Because of the limited scan sector, a scanning excursion was conducted using the CCO and the DVS. This excursion is described below.

Scanning Excursion

A dry-fire scanning excursion was executed during the day comparing the CCO from a standard firing position and the DVS from a reduced exposure position. Ideally, this exercise would have involved the DVS WFOV. However, because of the poor images in the WFOV, Soldiers used the NFOV. It is safe to assume that the results would differ if the DVS WFOV had been used, although they may not have been equivalent to the CCO results. It was anticipated that detection results would be better with the CCO, as Soldiers can use this optic with both eyes open, providing good central and peripheral vision. This was in contrast to the DVS 4 x 5 degree narrow field of view.

The firing scenario used for the scanning excursion, with target detection results, is shown in Table 10. Ten targets were presented; four at 75m, three at 175m, and three at 300m.

Only the 75m and 175m targets were presented as single exposures. The scenario called for 75m targets to appear in the farthest left and right lanes, resulting in a scan sector of 45 degrees from the 75m target in Lane 28 to the 75m target in Lane 32. Exposure times were consistent with the pattern used for marksmanship scenarios: longer times for more distant targets and for multiple (versus single) targets. Soldiers were shown the left and right limits of the sector prior to exercise start. Each Soldier scanned from Lane 30.

Four NCOs participated in this excursion. A data collector stood directly behind the Soldier to confirm whether the Soldier pointed at the appropriate target. This data controller also identified the lane and target distance. Two other data controllers recorded the time at which each target was detected. Considering all soldiers, of the 40 targets presented, 36 (90%) were detected with the CCO. For the DVS, 14 (35%) of the targets were detected. Figure 11 illustrates the range setup for the scanning excursion and the data collector's position relative to the firer.

Table 10
Scanning Excursion Scenario and Target Detection Results

Target Sequence & Exposure Time	**% Soldiers Detecting Target by Distance to Target**				
	Lane 28	Lane 29	Lane 30	Lane 31	Lane 32
CCO					
1 - 10 sec	75m 100%				
2 - 10 sec				175m 100%	
3 – 20 sec			75m 100%	300m 50%	
4 – 20 sec			175m 100%	75m 50%	
5 – 20 sec			300m 100%		75m 100%
6 – 20 sec	300m 100%				175m 100%
DVS NFOV					
1 - 10 sec	75m 25%				
2 – 10 sec				175m 25%	
3 – 20 sec			75m 75%	300m 0%	
4 – 20 sec			175m 75%	75m 25%	
5 – 20 sec			300m 0%		75m 25%
6 – 20 sec	300m 25%				175m 75%

Note. *n* = 4 Soldiers. Lane 29 was not used as the targets did not function.

Figure 11. Scanning excursion set-up.

Lethality

For day firing, the probability of hit (ph) was higher for the CCO than the DVS conditions in the 22-target field fire extended time scenario. But for both the KD and the 10-target field fire standard exposure scenarios, there were no differences in the sights.

For the night firing, the tendency was for the TWS direct view position to result in a higher ph than one or both of the TWS reduced exposure positions.

No differences occurred between the two reduced exposure positions (above and around a barricade) for either sight.

Considering all conditions and scenarios, the ph decreased significantly as the distance to the target increased. The ph values ranged from .84 to .88 at 75m, from .67 to .86 at 175m, and from .25 to .46 at 300m.

Round dispersion increased as the target distance increased.

For all sights, misses from the reduced exposure firing positions were symmetric with regard to windage.
Soldiers tended to aim low with the TWS, regardless of position, because of the unique thermal signature produced by the target and the soil conditions around the target.

Comparison with prior TWS reduced exposure data showed that training improved the ph. The ph increased by .24 and .33 at 75m and 175m respectively.

In the unobserved/unaimed fire scenario, no rounds hit the target.

Probability of Hit (ph)

For the KD and field fire scenarios, separate statistical analyses were conducted on the day and night firing. Each analysis was a two-way repeated measures analysis of variance (ANOVA) comparing three sight-firing position combinations and three target distances (75, 175, and 300m). Thus the day analyses compared the DVS above and around a barricade, and the CCO firing position conditions. The night analysis compared the TWS above and around positions, and the TWS direct view condition.

For the KD day firing, there was no difference among the CCO and DVS sight-firing positions (ph ranged from .62 to .74), but the ph decreased significantly with each increase in target distance (ph decreased from .88 to .70 to .41). For the TWS, the picture was not as simple. Again, there was a significant effect for target distance, with the ph decreasing at each distance (from .88 to .75 to .43). But there was also a significant main effect for sight-position (TWS direct higher than both reduced exposure positions, .81 vs. .67 and .58 for reduced exposure), and there was an interaction with target distance. The interaction showed that at 75m the TWS means were the same, but at 175m, TWS direct was higher than TWS above, and at 300m TWS direct was higher than TWS around. Means and ANOVA results are in Table 11.

Table 11
Probability of Hit per Soldier in the KD Scenario

Sight - Firing Position	Distance to Target			Each Sight-Position ph: All Distances
	75m	175m	300m	
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*
Day Fire (14 Soldiers)				
CCO Comparison	.97 (.07)	.73 (.26)	.51 (.33)	.74 (.32)
DVS Above	.80 (.30)	.64 (.29)	.39 (.41)	.61 (.45)
DVS Around	.86 (.27)	.72 (.27)	.33 (.39)	.64 (.45)
Target Distance ph for All Day Sight – Positions *(M[SD])*	.88 (.32)	.70 (.32)	.41 (.51)	
Night Fire (17 Soldiers)				
TWS Direct Comparison	.94 (.09)	.91 (.17)	.60 (.31)	.81 (.28)
TWS Above	.89 (.14)	.65 (.33)	.47 (.34)	.67 (.35)
TWS Around	.80 (.34)	.69 (.20)	.23 (.24)	.58 (.42)
Target Distance ph for All Night - TWS Positions *(M[SD])*	.88 (.21)	.75 (.35)	.43 (.35)	

Note 1. Day Fire repeated measures ANOVA results. Significant main effects for distance only.
No significant interaction.
Distance: $F(2, 26) = 34.51$, $p < .000$, partial $\varepsilon^2 = 73$. 75m > 175m and 300m, 175m > 300m.

Note 2. Night Fire repeated measures ANOVA results. Significant main effects for sight and distance.
Significant interaction.
Sight: $F(2, 32) = 11.83$, $p < .0001$, partial $\varepsilon^2 = .43$. TWS direct > TWS above & TWS around.
Distance: $F(2, 32) = 69.96$, $p < .000$, partial $\varepsilon^2 = .81$. 75m > 175m and 300m, 175m > 300m.
Sight x Distance: $F(4, 64) = 2.69$, $p < .038$, partial $\varepsilon^2 = .14$. At 75m, all TWS means the same; at 175m TWS direct > TWS above; at 300m, TWS direct > TWS around.

For the 22-target field fire scenario with extended exposure times, during the day firing, the ph with the CCO was significantly higher than that with the DVS above and DVS around reduced exposure positions. The ph with the CCO was .80 compared to .62 and .65 for the two reduced exposure positions. In addition, the ph decreased significantly as the distance to the target increased (decreased from .87 to .74 to .46). The means are presented in Table 12, and graphically illustrated in Figure 12.

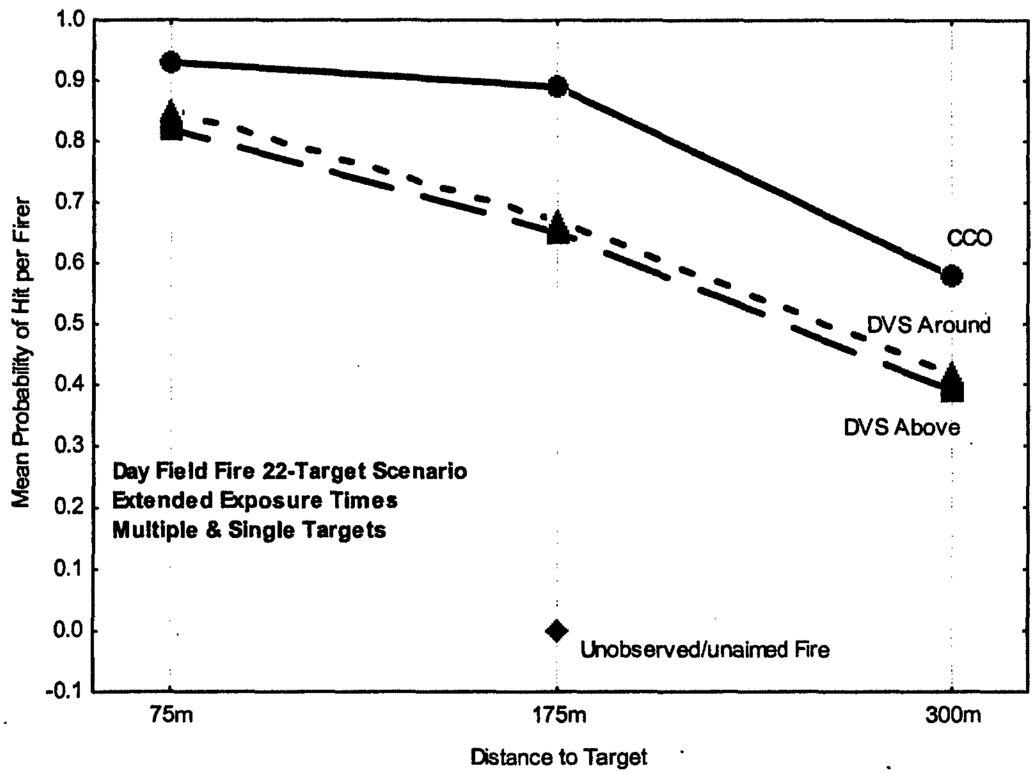
The night results were similar to the day results. The ph with the TWS direct view was higher than that with the two reduced exposure positions (.76 versus .61 and .60; see Table 12 and Figure 12). The ph also decreased significantly as the distance to the target increased (ph decreased from .84 to .73 to .41).

Table 12
Probability of Hit per Soldier in the 22-Target Field Fire Scenario with Extended Exposure Times

Sight - Firing Position	**Distance to Target** 75m *M (SD)*	175m *M (SD)*	300m *M (SD)*	Each Sight – Position ph: All Distances *M (S3)*
Day Fire (14 Soldiers)				
CCO Comparison	.93 (.11)	.89 (.11)	.58 (.20)	.80 (.13)
DVS Above	.82 (.20)	.65 (.25)	.39 (.31)	.62 (.38)
DVS Around	.85 (.17)	.67 (.24)	.42 (.34)	.65 (.32)
Target Distance ph for All Day Sights - Positions (*M[SD]*)	.87 (.19)	.74 (.26)	.46 (.26)	
Night Fire (17 Soldiers				
TWS Direct Comparison	.92 (.13)	.82 (.21)	.53 (.30)	.76 (.21)
TWS Above	.81 (.23)	.66 (.21)	.38 (.24)	.61 (.28)
TWS Around	.81 (.30)	.69 (.27)	.31 (.31)	.60 (.42)
Target Distance ph for All Night TWS Positions *(M[SD])*	.84 (.28)	.73 (.28)	.41 (.42)	

Note 1. Day Fire repeated measures ANOVA results. Significant main effects for sight and distance. No significant interaction.
Sight: $F(2, 28) = 6.77$, $p < .006$, partial $\varepsilon^2 = .33$. CCO > DVS above and DVS around.
Distance: $F(2, 28) = 57.20$, $p < .000$, partial $\varepsilon^2 = .80$. 75m > 175m & 300m, 175m > 300m.

Note 2. Night Fire repeated measures ANOVA results. Significant main effects for sight and distance. No significant interaction.
Sight: $F(2, 32) = 8.91$, $p < .001$, partial $\varepsilon^2 = .58$. TWS direct > TWS above & TWS around.
Distance: $F(2, 32) = 46.94$, $p < .000$, partial $\varepsilon^2 = .75$. 75m > 175m & 300m, 175m > 300m.



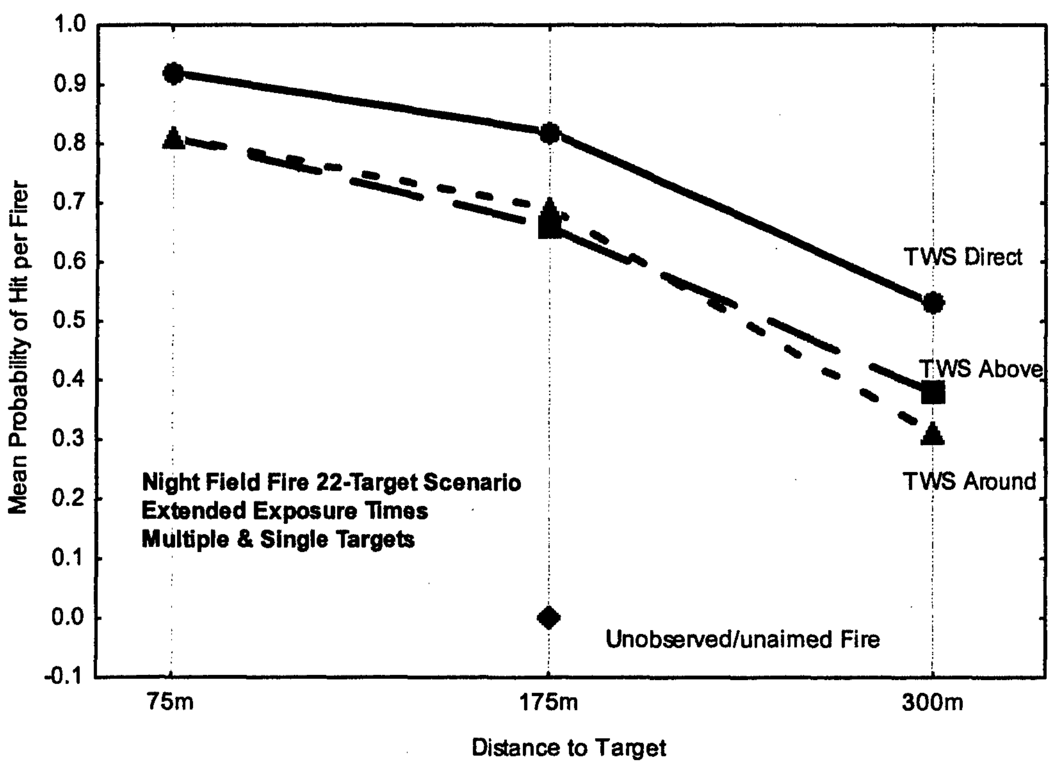


Figure 12. Day and night firing results for the field fire extended exposure time scenario.

For the 10-target field fire scenario with standard exposure times, during the day firing, there were no significant differences between the CCO and the DVS reduced exposure positions (ph ranged from .64 to 74). The ph decreased significantly at 300m (from .85 at 75m and 175m to .35 at 300m). The means are presented in Table 13, and graphically illustrated in Figure 13.

At night, the ph with the TWS direct view was significantly higher than that for the TWS around position (.68 versus .51). The ph also decreased significantly as the distance to the target increased (ph decreased from .85 to .67 to .25). The means are in Table 13 and graphically illustrated in Figure 13.

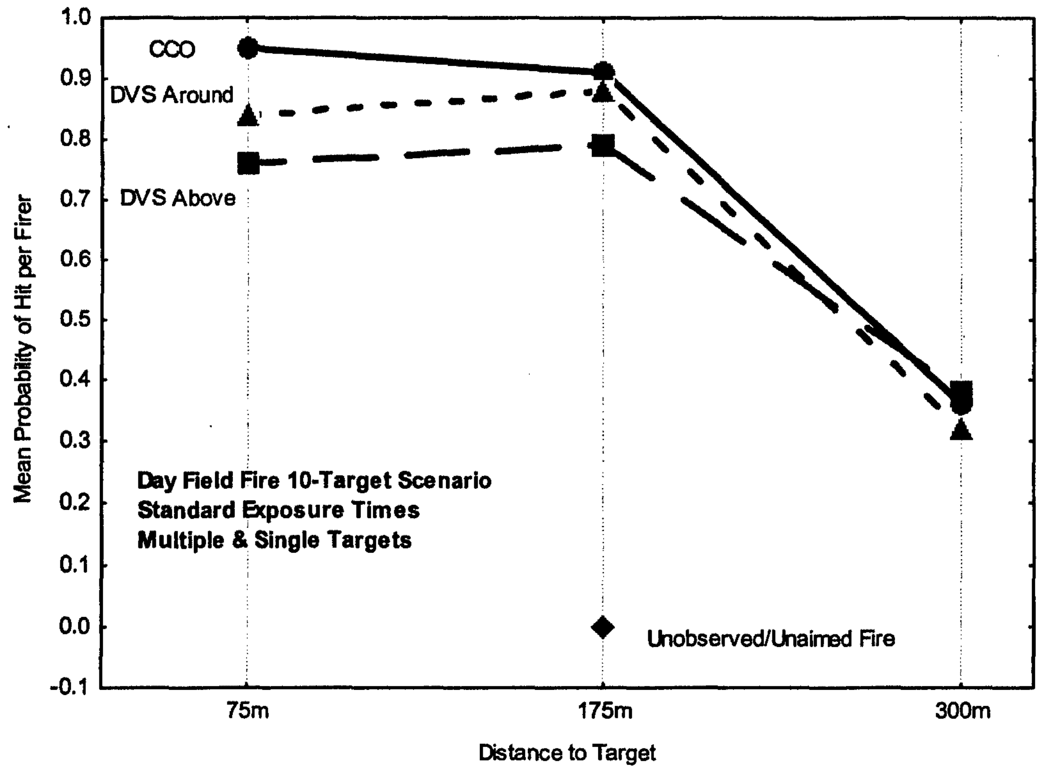
Table 13

Probability of Hit per Soldier in the 10-Target Field Fire Scenario with Standard Exposure Times

Sight – Firing Position	**Distance to Target**			Each Sight – Position ph: All Distances
	75m	175m	300m	
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*
Day Fire (14 Soldiers)				
CCO Comparison	.95 (.09)	.91 (.15)	.36 (.39)	.74 (.26)
DVS Above	.76 (.25)	.79 (.31)	.38 (.40)	.64 (.26)
DVS Around	.84 (.17)	.88 (.41)	.32 (.37)	.68 (.32)
Target Distance ph across All Day Sights – Positions *(M[SD])*	.85 (.19)	.86 (.19)	.35 (.45)	
Night Fire (17 Soldiers				
TWS Direct comparison	.92 (.17)	.86 (.17)	.26 (.41)	.68 (.28)
TWS Above	.76 (.20)	.62 (.35)	.35 (.41)	.58 (.35)
TWS Around	.88 (.24)	.53 (.30)	.14 (.29)	.51 (.35)
Target Distance ph by All Night TWS Positions *(M[SD])*	.85 (.21)	.67 (.28)	.25 (.35)	

Note 1. Day Fire repeated measures ANOVA results. Significant main effect for distance. No significant main effect for sight and no significant interaction.
Distance: $F(2, 28) = 35.12$, $p < .000$, partial $\varepsilon^2 = .72$. 75m > 175m; 175m > 300m.

Note 2. Night Fire repeated measures ANOVA results. Significant main effects for sight and distance. No significant interaction.
Sight: $F(2, 32) = 4.26$, $p < .02$, partial $\varepsilon^2 = .21$. TWS direct > TWS around.
Distance: $F(2, 32) = 69.84$, $p < .000$, partial $\varepsilon^2 = .81$. 75m > 175m & 300m, 175m > 300m.



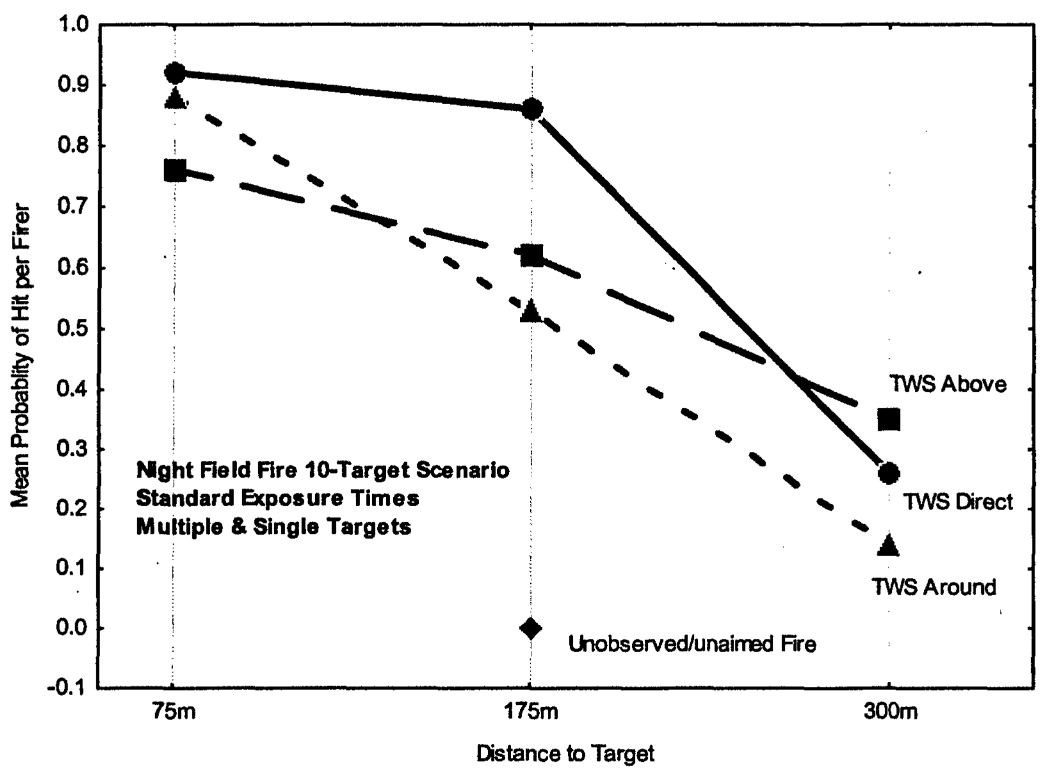


Figure 13. Day and night firing results for the field fire standard exposure time scenario.

In the standard exposure time field fire scenario, the ph at 300m with the TWS was low for all firing positions. Three factors indicated that Soldiers missed the target because they aimed low. First, during zeroing, some Soldiers rounds were not detected by the LOMAH system. Data collectors suggested the Soldiers aim higher on the hunch that the rounds would then be captured by the LOMAH system and shown in the graphical display on the FPE. When Soldiers raised their point of aim, their bullets were detected. Second, thermal camera pictures of the targets indicated the clay at the bottom of targets was still hot at night from the daytime sun. As shown in Figure 14, Soldiers could have easily treated the center mass of the target as lower than it was in reality. Lastly, Figure 15 shows that the hits at 300m were on the lower half of the target with the direct fire view. Almost none were on the upper half, indicating that Soldiers were aiming low with the TWS. Similar results occurred for the reduced exposure positions.

75m and 300m targets.

Image shows the clay at the bottom of some targets remained hot at night. 175m target is illustrated.

Figure 14. Thermal images of 75, 175, and 300m targets at night.

Impact of Training

The reduced exposure data from the TWS were compared to historical data (Dyer et al., 2000) available from the train-up of a LW-equipped platoon stationed at Ft. Bragg, NC for the Joint Contingency Force Advanced Warfighting Experiment (JCF AWE) in 2000. Version 0.6 of the LW system was used. There was no time available to train the Soldiers on reduced exposure positions prior to firing. Thus these historical data provided a training baseline for comparison with the trials in the experiment reported here.

There were several differences between the conditions at Ft. Bragg in 2000 and Ft. Benning in 2003. In 2000 the Soldiers used the medium TWS. All fired from a foxhole position; there was no barricade; Soldiers were told to keep their head down. Figure 16 illustrates some of the positions that were used. At Ft. Bragg, Soldiers fired a record fire scenario. The Soldiers at Ft. Bragg were all 11B Infantrymen, whereas that was not the case in the reduced exposure experiment documented in this report.

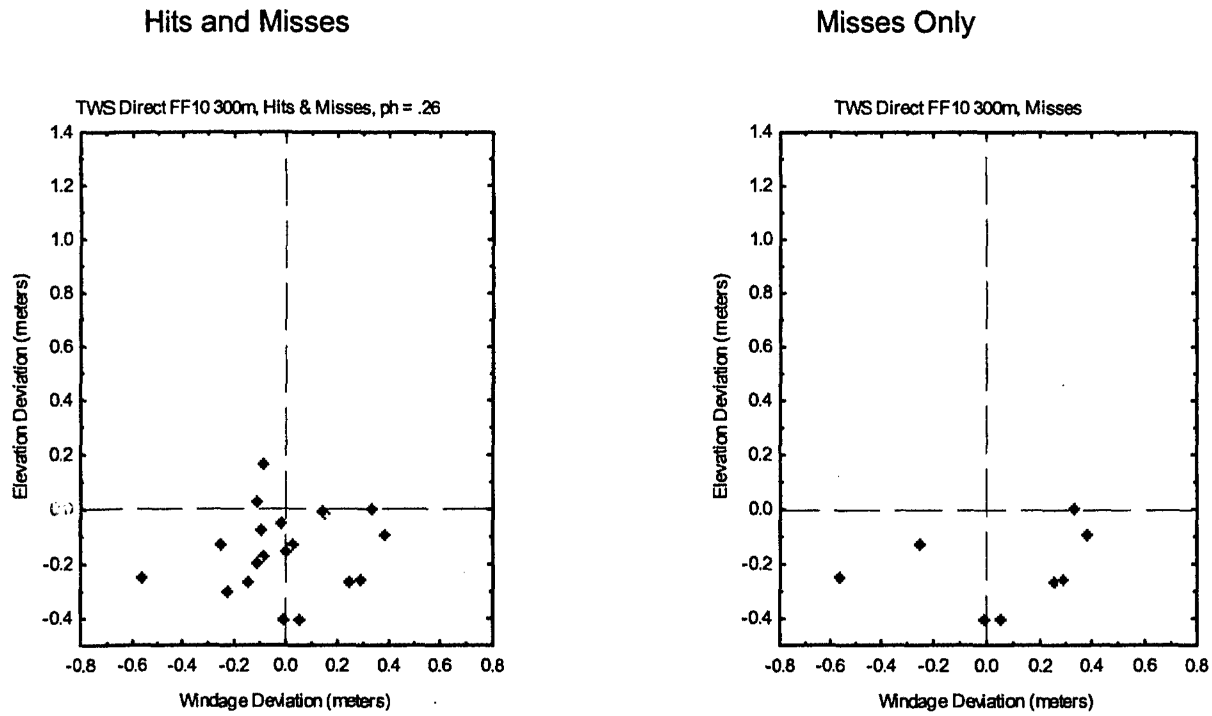


Figure 15. Round location at 300m with TWS direct view and 10-target field fire scenario.

The reduced exposure data from the train-up for the JCF AWE firing was compared to the reduced exposure results from the current trials and are graphically depicted in Figure 17. The distances to the target differed as the range used at Ft. Bragg was a record fire range. In addition, there were no 250 and 300m targets in the scenario used at Ft. Bragg. The ph results at 75m and 175m were estimated from the Ft. Bragg data and compared to the standard exposure field fire results in the reduced exposure experiment[5]. At 75m, the estimated ph was .57 as compared to .81 in the standard exposure scenario (increase in ph = .24). At 175m, the estimated ph was .25 versus .58 in the standard exposure scenario (increase in ph = .33).

Figure 16. Reduced exposure positions used by LW platoon at Ft. Bragg during train-up for the JCF AWE.

[5] The 75m estimate was the mean of 50m and 100m. The 175m estimate was the mean of 150m and 200m.

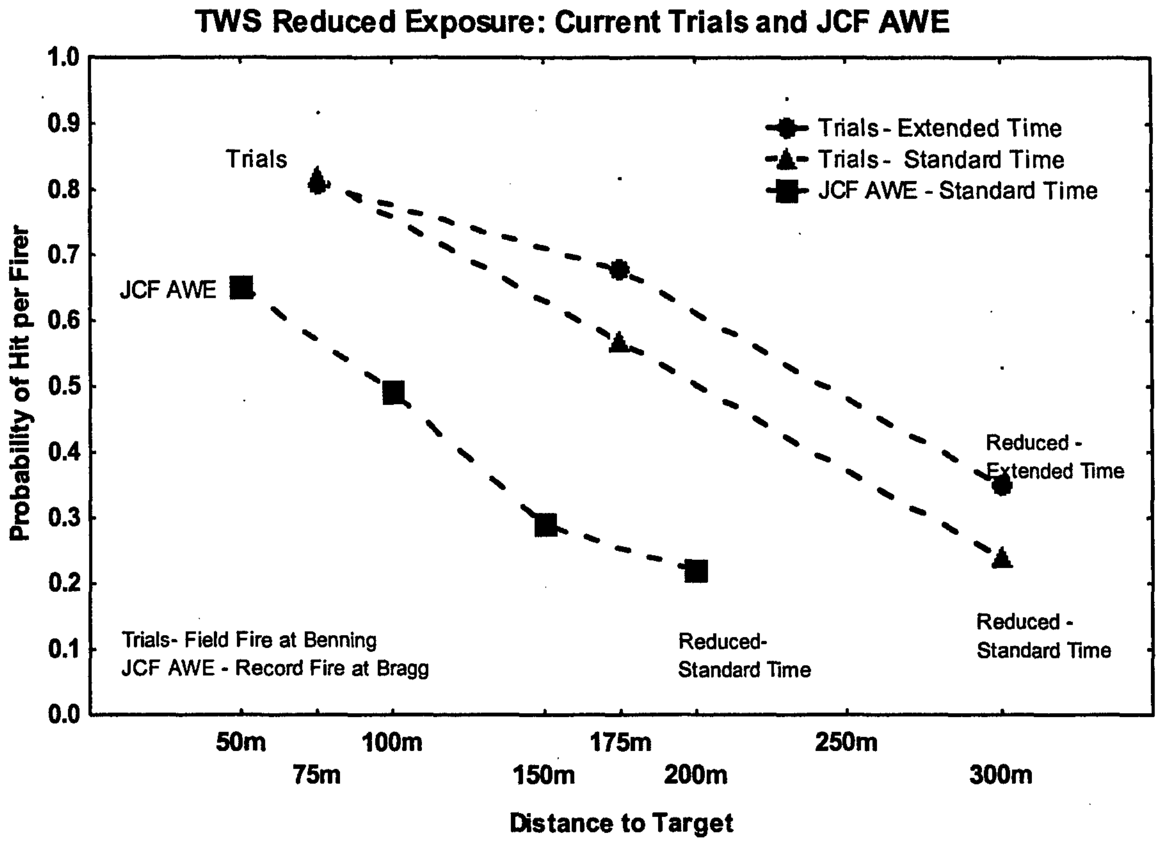


Figure 17. TWS probability of hit results from the reduced exposure trials and during the train-up for the JCF AWE.

Unobserved/unaimed Fire

The last scenario that related to the lethality results was the unobserved/unaimed fire scenario. These results were clear. Of 155 rounds fired, no rounds hit the 175m target. The probability of hit was zero (0). Only 5 rounds (all misses) were detected by the LOMAH system.

Round Location and Accuracy

Round location and accuracy were assessed by radial miss distance (RMD) and with scatter plots showing the exact locations of the rounds that were detected by the LOMAH system. As expected, results indicated greater dispersion of rounds as the distance to the target increased. Round location and accuracy were examined with the KD and the two field fire scenarios.

Table 14 presents the average RMD, in meters, across all Soldiers for each sight-position and target distance combination. The LOMAH system provided the x and y distances (horizontal and vertical) from center of mass of each target for each round that fell within the LOMAH detection zone. The x and y values were then converted into RMD values with the following formula:

$$RMD = \sqrt{(x^2 + y^2)}$$

The RMD is the distance from the bullet location to the center mass of the target (diagonal of the triangle created by the x and y distances, as shown in the graphic below.

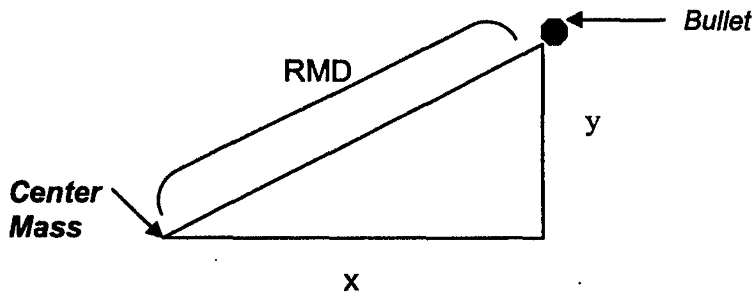


Table 14 presents the RMD for both target hits and misses as detected by the LOMAH system. Although the KD scenario was designed as the primary means for determining shot location, the two field fire scenarios were also used. To put the RMD data into context, the height of E-silhouette target, placed at 175m and 300m, is .95m (to top of head) and the width (body) of the target is .49m. The head is .21m wide; the shoulders are .68m from the ground.

Table 14
Mean Radial Miss Distance (meters) for Hits and Misses

Known Distance Scenario						
	75m		175m		300m	
	n	RMD	*n*	RMD	*N*	RMD
CCO	69	.09	138	.23	58	.31
DVS Above	68	.14	137	.26	41	.33
DVS Around	65	.10	128	.22	44	.32
TWS Direct view	83	.08	169	.19	67	.25
TWS Above	80	.11	167	.28	61	.31
TWS Around	72	.09	153	.23	42	.38
22-Target Field Fire Scenario with Extended Times						
CCO	106	.12	137	.18	76	.28
DVS Above	110	.16	125	.27	50	.31
DVS Around	109	.18	128	.25	58	.33
TWS Direct View	122	.12	148	.20	70	.27
TWS Above	122	.15	145	.25	58	.32
TWS Around	117	.15	132	.23	44	.32
10-Target Field Fire Scenario with Standard Times						
CCO	60	.11	43	.18	32	.33
DVS Above	68	.23	40	.20	20	.31
DVS Around	63	.20	39	.18	26	.34
TWS Direct View	71	.15	47	.18	20	.27
TWS Above	67	.19	41	.22	23	.30
TWS Around	70	.17	46	.28	12	.32

Note. *n* refers to the number of rounds.

The RMD for hits and misses with the direct view positions were smaller in 33 of 36 comparisons with each reduced exposure position. The three exceptions were in the day firing, where the RMD for DVS around position was smaller than the RMD for the CCO at 175m (KD and 10-target scenarios), and the RMD for the DVS above position was smaller than the RMD for the CCO at 300 m (10-target scenario)

As was expected and as reflected in the scatterplots (see Figures 18 and 19 and Appendix G), the RMD for hits and misses increased with each increase in target distance. There were only 3 exceptions to this pattern (Table 16). All were with the DVS; KD with DVS around position and the 10-target scenario with DVS above and DVS around.

The RMD for hits only was also examined (see Table F-3). These data were not as reliable as the hit/miss data, due to the smaller number of hits, particularly at 300m for the 10-target scenario. For hits only, the direct view positions resulted in the smaller RMD in 26 of the 36 comparisons. The 10 exceptions to this pattern were distributed across 175m and 300m, where the RMD values for reduced exposure positions were smaller. Eight of these ten exceptions were the DVS at both 175m and 300m. The two TWS exceptions were at 175m.

As with the hits and misses data, the RMD values for hits only increased with each increase in target distance, with 3 exceptions to this pattern. All were with the DVS: KD with the DVS around and around positions, and the 22-target scenario with DVS above.

With hits only, the instances where the RMD size was smaller for reduced exposure positions were all at 175m and 300m with the DVS. There are several possible explanations for why the DVS RMD was smaller than the CCO RMD. These factors could have worked independently or jointly. One reason could be the difference in magnification between the CCO and the DVS. Soldiers fired in the 4 power NFOV with the DVS, which allows more precision than the CCO with its unity power. A second reason could be because the DVS cross-hair reticle allows a more precise aim point at the longer target distances. The CCO's 5mm red dot covers the width of an E-silhouette at 300m, which does not provide a precise aim point. A third possible reason relates to the DVS WFOV, which is 4° by 5°. This small FOV could increase the firer's concentration on the target, as his focus of attention is limited to a smaller area than when using the CCO.

Appendix G contains graphical illustrations of the location of hits and misses for each scenario (KD, 22-target field fire with extended exposure times, and 10-target field fire with standard exposure times). Each page in the Appendix represents a specific target distance (75, 175, or 300m) from a scenario. The left half of the graph shows all the hits and misses; the right half shows misses only. Each row in the graph illustrates a different sight-position condition, thereby juxtaposing the hits/misses and misses only illustrations according to each sight-position condition. This two-by-three layout allows a comparison of what happened to the Soldiers' rounds at each target distance for day or night fire.

Figures 18 and 19 show two pages from Appendix G. Figure 18 shows the results of KD day firing at 175m; Figure 19 shows the same scenario and distance for night fire. The vertical and horizontal lines within each scatterplot intersect at the center mass of the target, and provide a reference for vertical and horizontal location of the bullets. In both figures, the scatterplots showed slightly greater dispersion of rounds with the reduced exposure firing positions and with an increase in target distance. These graphs are consistent with the RMD values in Table 14. In addition, the "misses only" graphs do not indicate any bias with regard to windage from the reduced exposure positions. With the exception of the TWS in the 10-target scenario at 300m, the patterns of hits and misses were generally similar for day and night firing.

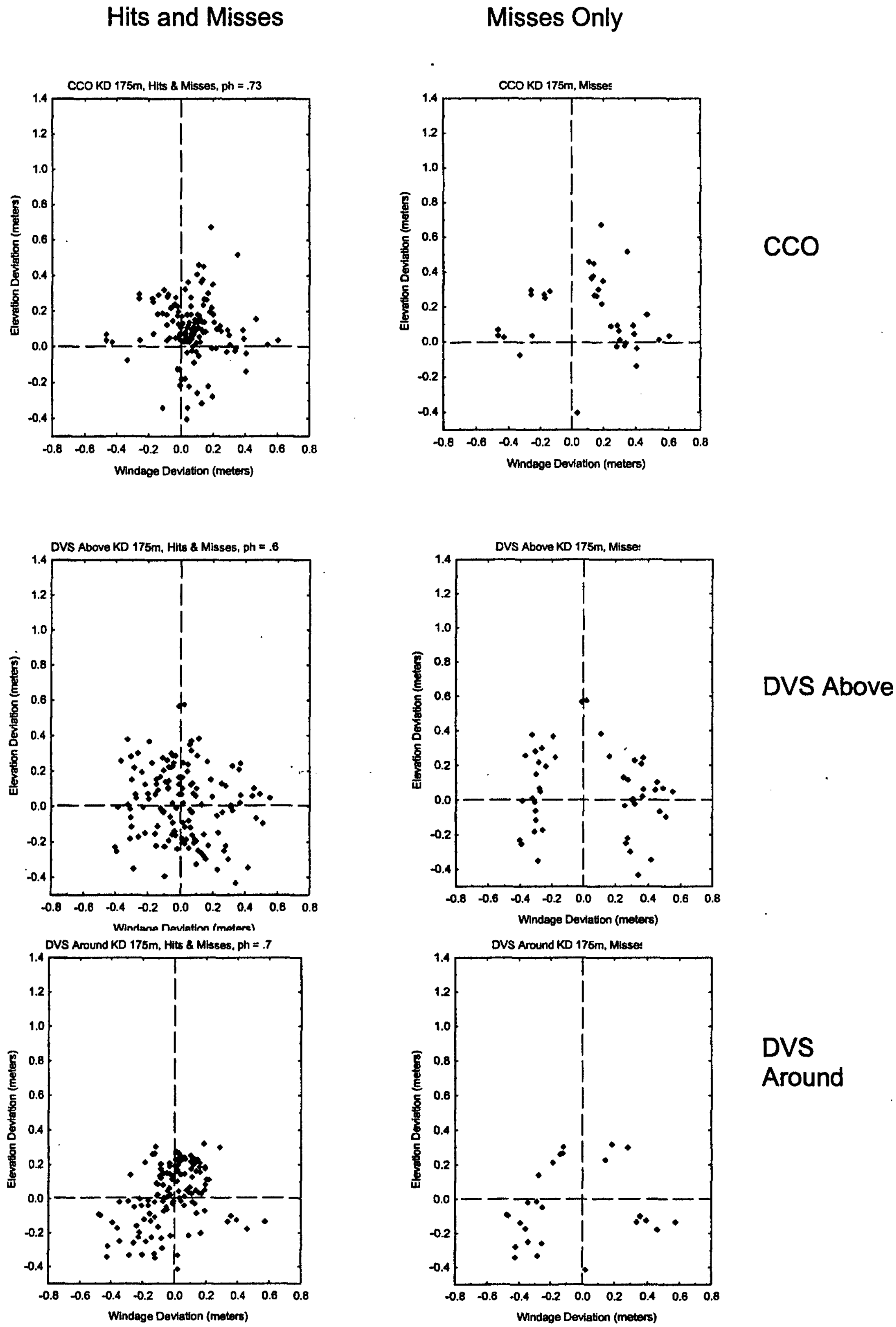


Figure 18. Scatterplots of hits and misses for KD day firing at 175m.

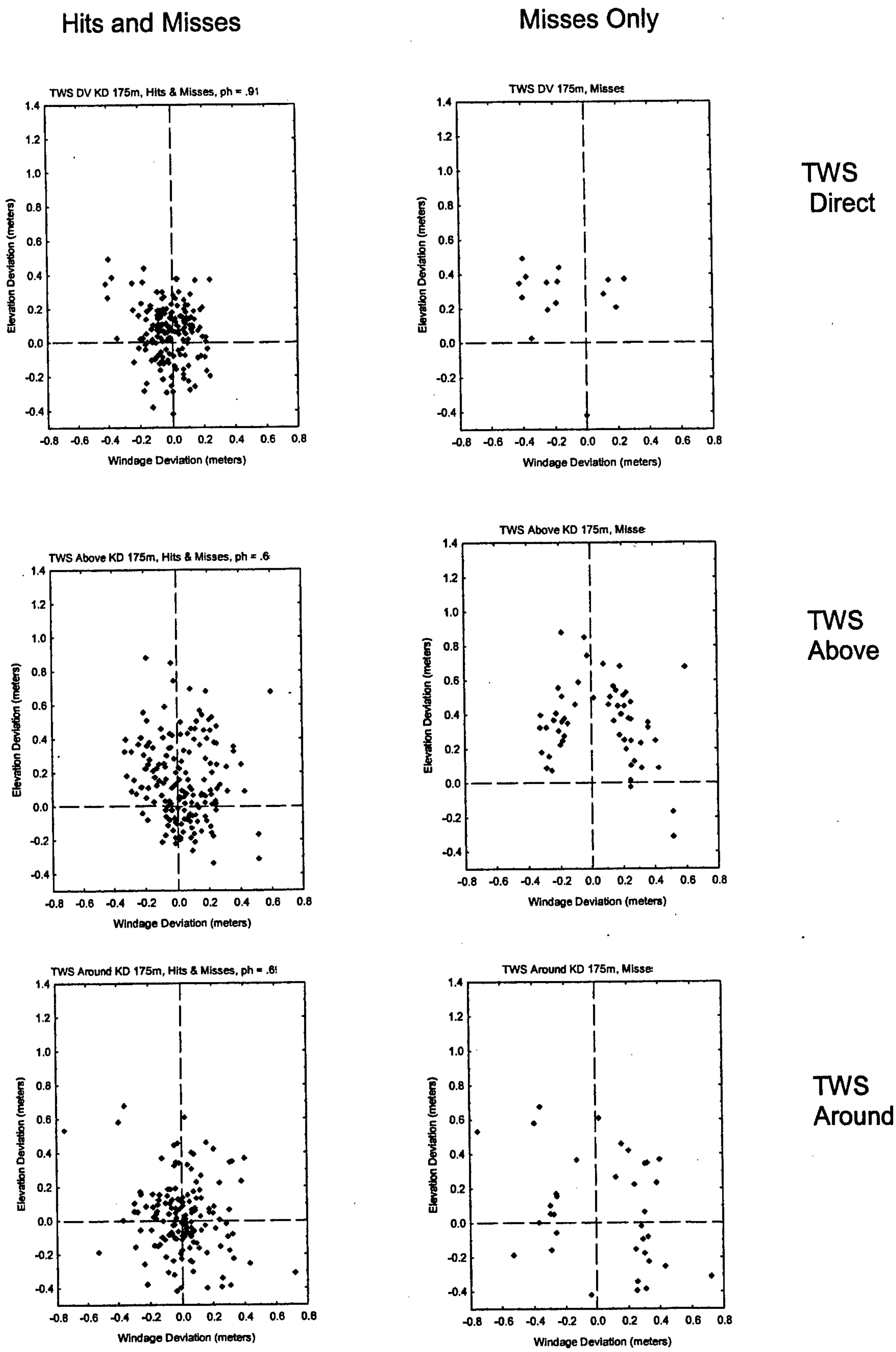


Figure 19. Scatterplot of hits and misses for KD night firing at 175m.

Hasty Firing Position Excursions

> *Hasty positions for firing around a barricade (corner) using the DVS, with and without a sling on the weapon, were tried with a limited number of Soldiers.*
>
> *Weapon stability was critical to hitting from these positions. Observations indicated that a sling helped Soldiers obtain a stable position quicker and easier compared to firing without* a sling.
>
> *Soldiers must be trained on how to use a sling for reduced exposure firing.*

Excursion 1- Firing Around a Corner

The initial examination of assault- or hasty-type positions involved one Soldier simulating shooting around a corner. A heavy table was used to simulate a wall, and the Soldier could brace himself against it. The Soldier used a modified kneeling position as shown in Figure 20. A sling was not used. The scenario was the 22-target field fire scenario with extended exposure times. For comparison purposes, the same individual fired the same scenario from a prone, direct view position using the CCO.

For the first eight rounds with the DVS, the Soldier did not have a stable firing position. After the eighth round, he adjusted his arm to provide more support for the butt of the weapon, and his firing performance changed dramatically. As shown in Table 15 below, initially no targets were hit with the DVS. After assuming a more stable position, shooting performance was the same as the CCO; 9 hits out of 14 targets with the CCO and 10 hits out of 14 with the DVS.

Table 15
Results for Excursion 1 – Shooting Around a Corner

Distance to Target	**CCO**		**DVS**	
1st 8 targets	# Targets Hit	Percentage	# Targets Hit	Percentage
75m	3 of 3	100%	0 of 3	0%
175m	3 of 3	100%	0 of 3	0%
300m	1 of 2	50%	0 of 2	0%
Total	7 of 8	87%	0 of 8	0%
Last 14 targets				
75m	4 of 4	100%	3 of 4	75%
175m	4 of 6	67%	6 of 6	100%
300m	1 of 4	25%	1 of 4	25%
Total	9 of 14	64%	10 of 14	71%
All Targets	16 of 22	73%	10 of 22	45%

Note. 22-target Field Fire scenario with extended exposure. One Soldier.

Figure 20. Initial no-sling excursion with one Soldier (Week 2).

Excursion 2 - Sling and No Sling Comparisons

During Week 4, additional firing excursions were conducted comparing hit performance with and without a sling. The scenarios were both KD and field fire. Three Soldiers participated in these excursions, although every Soldier did not fire every scenario – position combination. Figure 21 illustrates the positions used by Soldiers in this excursion. Table 16 presents the results.

Although there were no strong distinctions between the sling and no-sling positions, data controllers noted that the sling provided the means to obtain a stable position quickly. To establish a stable position without a sling was more difficult. In addition, the sling was less tiring for the Soldier.

Table 16
Number of Hits in Sling and No Sling Hasty Firing Positions

Soldier	Sling			No Sling		
	KD: 75m 10 targets	KD: 175m 10 targets	FF: 75 & 175m targets	KD: 75m 10 targets	KD: 175m 10 targets	FF, 75 & 175m targets
A	8 of 10	4 of 10	8 of 10 (5 at 75 & 3 at 175)	8 of 10	4 of 10	3 of 10 (2 at 75 & 1 at 175)
B	3 of 10	1 of 10	Not fire	5 of 10	5 of 10	Not fire
C	9 of 10	6 of 10	6 of 10 (4 at 75 & 2 at 175)	Not fire	Not fire	Not fire

Note. In the Field Fire scenario, there were 5 targets each at 75m and 175m.

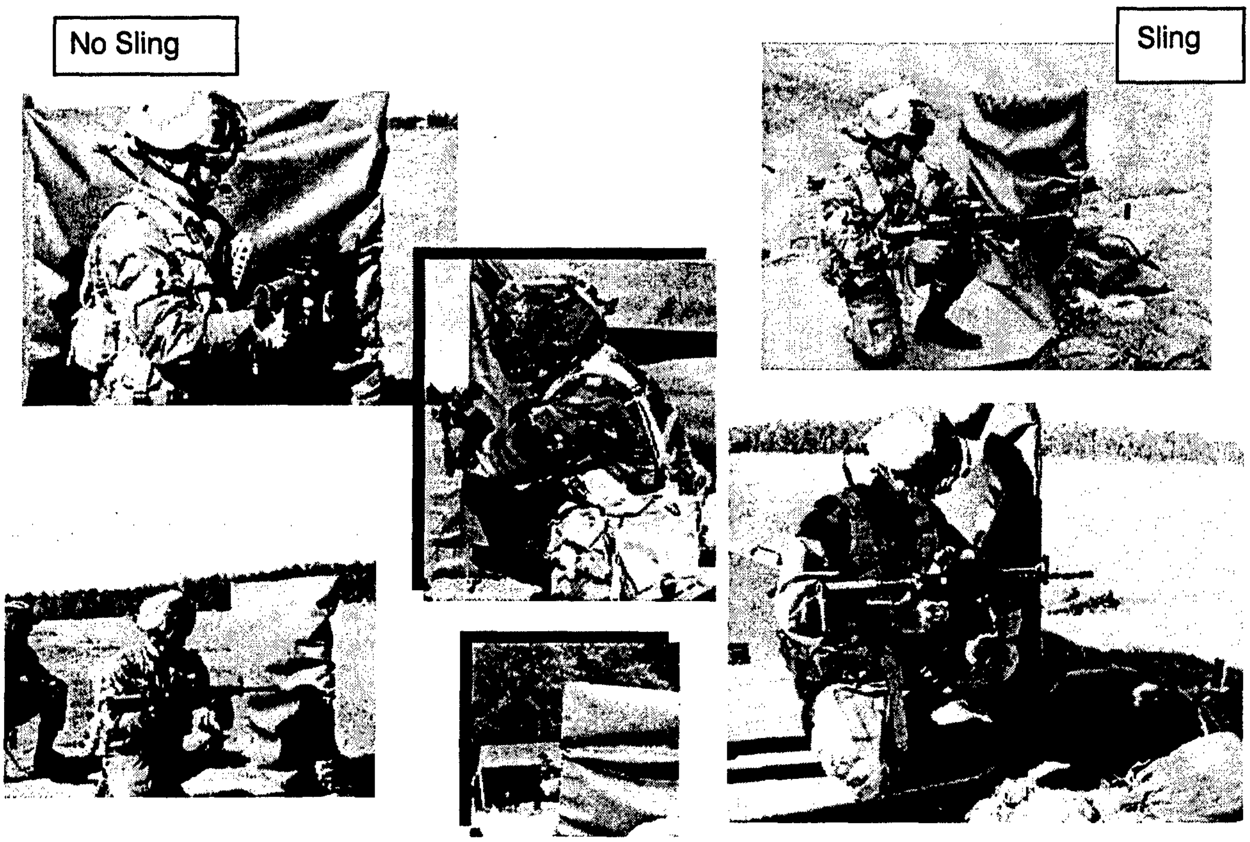


Figure 21. Sling/no-sling excursions (Week 4).

Some background information on the Soldiers is useful when interpreting these results. Soldier A owned several slings and was quite comfortable firing with a sling. Neither Soldier B nor C had used a sling before. Soldiers A and C were NCOs.

Soldier Exposure – Survivability

The results from the Soldier exposure measurements are shown in Table 17. The reduced exposure positions did result in less of the firer's body being exposed to the enemy. The amount of exposure with the LW system for each Soldier was less from the firing above a barricade position, averaging 82% less (1-(14.88/82.42)) than the corresponding current direct view position. For the firing around a barricade position, the same pattern occurred, with an average of 72% less (1- (46.75/166.83)) exposure. The absolute amount of exposure of the Soldier's body shown in Table 17 also indicates that the Soldier would be very hard to detect.

Table 17
Soldier Exposure in Direct View and Reduced Exposure Positions

Soldier	Amount of Exposure in Square Inches					
	Above a barricade position			Around a barricade position		
	Direct view (DV) without LW	Reduced with LW	Ratio: DV to Reduced	Direct View without LW	Reduced with LW	Ratio: DV to Reduced
A	104.00	10.66	9.75	195.02	56.12	3.47
B	85.81	17.87	4.81	167.15	44.81	3.73
C	79.01	16.50	4.79	158.42	41.27	3.83
D	74.20	14.22	5.21	177.46	43.90	4.04
E	68.98	15.15	4.53	136.08	47.66	2.85
Mean	82.42	14.88	5.82	166.83	46.75	3.59

In the Katz et al. (2001) study, six firing postures were examined: prone behind a tree, standing behind a tree, prone in depression, kneeling beside a window, and standing beside a doorjamb both right-handed and left-handed. The prone from behind a tree was the one most similar to those used in the current trials. Specifically it was similar to firing around a barricade. However, the measurement technique to assess the amount of exposure was less accurate than that used in the trials (see Figure 5). In the prior effort, the amount of exposure was based on a rectangle. The height of the rectangle was the distance from the ground to the highest part of the firer that was exposed. The width of the rectangle was the greatest extension of the firer's body from the barricade (tree, window, etc.). Thus the rectangle included some "space" where there was no Soldier or Soldier equipment.

Katz et al. also calculated the probability of being hit by the enemy. These calculations were based on the rectangle measurements and on three weapons/ammunition combinations: AK74 with 5.45.mm ammunition; AK47 with 7.62 mm ammunition, and PKM with 7.62mm ammunition. [6]

[6] The probability of the enemy hitting the firer (two-dimensional exposed area) was based on the rectangular measurement, and the biases and dispersions of the weapon/ammunition combination provided by the U.S. Army Material Systems Analysis Activity.

Katz et al. found that the exposure of a firer to the enemy using a reduced exposure position when firing from behind a tree was 63% less compared to the direct fire position from behind a tree. In the trials, the average exposure from firing around a barricade was 72% less (see Table 23). Of interest is that Katz et al. found that the probability of being hit by the enemy when in a reduced exposure prone position behind a tree, averaged across the three enemy weapon systems, was 63% less than the likelihood of being hit when in a direct view position from behind a tree. This one-to-one correspondence between the reduction in exposure and the reduced likelihood of being hit also existed for the kneeling beside a window and the prone in a depression positions.

Based on the reduced exposure trial results, it is reasonable to assume that firer survivability does increase by being in a reduced exposure position. Applying the best case and worst case survivability rates found by Katz et al. (2001) to the exposure data reported here, the estimates of a Land Warrior Soldier's chances of not being hit are 2.7 to 4.5 times greater in a reduced exposure position than in a direct view position.

Discussion and Conclusions

The experiment was the first systematic attempt to quantify the effects of reduced exposure fire and to identify the challenges with this technique of fire. The findings have multiple applications for the Army. They provide critical information on the lethality that can be achieved by Soldiers using the LW system in reduced exposure firing positions, and on Soldier survivability. They provide accuracy and survivability data for use in constructive and virtual simulations. They provide information on reduced exposure training procedures and practice scenarios, training time, and training resources. Lastly, they provide a basis for developing reduced exposure firing standards.

Training

Clearly, Soldier success with reduced exposure firing depends on training. Comparison with historical data showed that training had a substantial impact on reduced exposure probability of hit at all target distances with the TWS (overall increase of .28 in ph). At 75m, the Soldiers trained in the current experiment achieved a hit probability of .81 versus a hit probability of .57 for the Solders with no reduced exposure training in the prior JCF AWE (Dyer, et al, 2000). At 175m, the corresponding hit probabilities were .58 (trained) versus .25 (not trained).

Several observations were made during the experiment regarding how Soldiers acquired expertise. These included the following:

- Zeroing at 175m, versus the usual 25m, and confirming zero on each subsequent day probably had positive effects on performance. Soldiers knew they could hit targets at a distance and that their zero was "good." In addition, confirmation of zero insured that any changes Soldiers made in their sight picture and/or any additional skills acquired from using the sights (DVS, TWS, CCO) were integrated into their zeroing procedures.
- The Soldiers' skill and rate of learning varied with prior marksmanship experience, and experience with similar sights. For instance, NCOs who had substantial experience with the CCO zeroed more quickly and typically had fast rates of fire during zeroing and the

KD scenarios. NCOs with prior thermal sight experience also adapted quickly to the TWS.

- A stable firing position was critical to hitting targets. Soldiers differed in the ease or speed with which they achieved such a firing position. It seemed that the privates took the longest time and required the most one-on-one coaching in this regard. It was important that each individual determine the position that worked best for him. Forcing individuals into a fixed posture did not work, given the individual differences in physical size and in the marksmanship backgrounds of the Soldiers.

- Of interest was that a Soldier was consistent in his preferred firing position (foxhole or prone) with the two sights. In addition, Soldiers were about evenly split on whether they used a prone position or a foxhole position.

- Although the left-handed and/or left-eye dominant Soldiers could fire right handed in a reduced exposure position, most of these Soldiers found they performed best if they did not change to firing right-handed. It was important to be consistent with the marksmanship techniques and expertise already developed. When trying to fire right handed, some of these Soldiers tended to modify their position slightly from round to round (placement of butt stock in shoulder, position of head, etc.) indicating they were not comfortable. Once they switched to firing left-handed, these movements stopped.

- The practice training exercises reflected an effective building block approach for integration of skills. Dry-fire was an inexpensive technique that provided good initial feedback on the Soldier's ability to acquire targets. The known distance live-fire exercise reduced demands on target acquisition, while stressing the Soldier's ability to hit a target. The field fire practice scenarios that followed combined both skills.

- Field fire scenarios that modified the time of target exposure were also valuable training techniques. The extended exposure scenarios allowed time for the Soldier to gain confidence in hitting targets, before encountering the typical shorter exposure times.

Not all training questions were addressed in this initial experiment. Less information was obtained on how to train Soldiers to fire from hasty firing positions, and to scan large sectors of fire. The results did show, however, that a sling assisted with hasty positions, and that additional training is needed with Soldiers who have no prior experience with a sling. No data were obtained on when and how to best change fields of view to assist in either target observation or engagement. The scanning excursion results showed, however, that there was a need for training exercises that addressed these skills, and a need to determine how target detection varies as a function of the sector of fire and the field of view used by the firer. Also not all reduced exposure positions were examined; nor was the impact of reduced exposure firing on tactics, techniques, and procedures examined.

The results and observations during the experiment were used to develop a training plan for reduced exposure firing. This plan is at Appendix H.

Equipment Design

The experiment had several implications for design of the DVS and Soldier equipment. A sling is needed for hasty firing positions, although there was no attempt to compare the relative merits of different slings in the experiment.

The results of the experiment did impact the revised design of the DVS used for the Stryker Integration version of the LW system (LW-SI). The characters in the reticle display were made legible. The zero adjustments for windage and elevation were made consistent with other weapon sights. The authors also understand that the most recent version of the DVS provides clearer images.

Measuring and Diagnosing Soldier Performance

Data collectors used traditional means of recording marksmanship performance. However, the additional use of the LOMAH system greatly facilitated the scenarios developed for the experiment, increased the precision of the data, and provided results that would not have been possible otherwise.

LOMAH allowed the sequence of shots to be recorded as well as the location of each shot from center of mass. This allowed a quick diagnosis of how each Soldier was progressing during the training, tightness of shot groups during zeroing, and how to adjust sights to establish a zero. Knowledge of miss location was also critical examining the impact of reduced exposure firing. The majority of misses were sufficiently close to the target to be considered suppressive fire. So when a Soldier missed the target, he may have suppressed it. The LOMAH measures helped explain results and verify hypotheses about outcomes, as illustrated by the low TWS probability of hit at 300m in certain scenarios. Use of a LOMAH system would be essential in future investigations of reduced exposure fire.

Lethality

The original expectations regarding lethality were confirmed in the experiment, as reduced exposure accuracy was less than that obtained with direct view firing. However, the decrease was not great, and was not statistically significant for all comparisons (day/night and target distance). There was a slight decrease in hit probability with reduced exposure firing positions compared to direct view firing (overall difference of 0.13 in ph). For day firing, the overall hit probability was .77 with the CCO versus .65 with the DVS. For night firing, the overall hit probability was .72 with the TWS direct view mode versus .58 using the TWS in reduced exposure posture.

Whether additional practice and experience would reduce the difference between direct view firing and reduced exposure firing is an empirical question. It should be mentioned however, that the differences were not a result of using the HMD, as there is a direct digital link from the DVS and the TWS to the HMD. In fact, with some of the TWSs, there was condensation in the optical subsystem of the sight itself which obscured parts of the target when the Soldier used the direct view. This obscuration was not present when using the TWS in conjunction with the HMD, as the digital image went directly to the HMD.

The largest difference was the comparison between the reduced exposure lethality and that obtained with unobserved/unaimed fire. With unobserved/unaimed fire, Soldiers did not hit any targets; the probability of hit was zero and the likelihood of a missed bullet being detected by LOMAH was 3 chances out of 100 (.03). Although unobserved/unaimed fire is not an approved technique of fire, Soldiers have used it in combat situations when pinned down and they want to suppress the enemy. The LW system with reduced exposure capability would provide a substantial advantage to Soldiers in such situations.

It was surprising to find that there was no bias in round location with regard to windage with the reduced exposure firing technique. RMD and round location results were generally consistent with expectations: an increase in RMD with increased distance to the target, and reduced exposure positions resulting in higher RMD values. The exception to this pattern was when hits only were examined. There was a tendency for the DVS RMD values to be smaller at the longer ranges as compared to the CCO. This was attributed to Soldiers using the narrow field of view (4x magnification), a reticle that allows a more precise aim point, and the small field of view that focuses the Soldier's attention on a smaller area when firing.

Survivability

Soldier exposure was 75% less than that in current, direct view positions. Although survivability was not measured directly, the reduction in exposure should result in greater survivability. In addition, it should be pointed out that absolute amount of exposure was extremely small, making it very difficult for a enemy to detect a Soldier in a reduced exposure firing position.

Future Research

The results clearly show the benefits from the reduced exposure technique of fire. But the picture is not complete without further investigation. Future research should build on the current database and knowledge gained in this experiment. The current experiment identified three major areas that need to be examined in more depth. First, there is a need to examine target acquisition proficiency as a function of the size of the sector of fire. The tactical advantages of conducting surveillance when the firer has a very low probability of being detected needs to be thoroughly examined. It could be that scanning/surveillance is used more frequently in combat situations than engaging targets. Second, more research is needed on how to train Soldiers to quickly detect and engage targets from various offensive, hasty firing positions. Given that urban combat conditions are common place, the importance of determining what is required to train Soldiers in this environment is critical. Third, research is needed on how to train Soldiers to detect, acquire and hit moving targets, from both hasty and defensive reduced exposure positions. This is a higher level of skill than was investigated in the present experiment.

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Appendix A

Test and Practice Scenarios

Table A-1

Target Sequence in the Live-Fire Test Scenarios

Target Acquisition (Scenario A) 6 targets, field fire scenario		**Field Fire w/ Extended Exposure Times (Scenario C)** 22 targets		**Field Fire w/ Standard Exposure Times (Scenario D)** 10 targets	
Target Sequence	Exposure time (sec)	Target Sequence	Exposure time (sec)	Target Sequence	Exposure time (sec)
300m	10	175m	10	75m	5
175m	10	75m, 300m	20	175m	7
75m	10	75m, 175m	20	75m, 300m	11
300m	10	300m	10	75m, 175m	9
175m	10	75m, 175m	20	75m, 300m	10
75m	10	175m, 300	20	175m, 300m	11
		75m, 175m,	20		
		175m, 300m	20		
		75m	10		
		175m, 300m	20		
		75m, 175m	20		
		75m, 300m	20		
		175m	10		
Known Distance, Scenario B. 5 targets at 75m, then 10 targets at 175m, and lastly 5 targets at 300 m. Targets at each distance remained up until all rounds were fired.					

Note. On all field fire scenarios, there was 2 seconds between target presentations. This was a built-in function of the LOMAH system.

Table A-2

Target Sequence in the Practice Reduced Exposure Scenarios used for Practice

Practice Dry Fire (first practice scenario)		**Practice Live-fire: Field Fire with Extended Exposure Times** (third and last practice scenario)	
Target Sequence	Exposure time (sec)	Target Sequence	Exposure time (sec)
75m	10	75m	10
175m	10	175m	10
300m	10	75m, 300m	20
175m	10	75m, 175m	20
75m	10	75m, 300m	20
300m	10	175m, 300m	20
300m	10		
75m	10		
175m	10		
175m	10		
300m	10		
175m	10		
75m	10		
300m	10		
175m	10		
75m	10		
300m	10		
75m	10		

Known Distance (2nd practice scenario). The known distance scenario was the same as the test scenario: 5 targets at 75m, then 10 targets at 175m, and lastly 5 targets at 300 m. Targets at each distance remained up until all rounds were fired.

Appendix B

Practice and Test Scenario Data Collection Forms

Tuesday

Practice with DVS dry fire

Soldier's name____________________ Soldier #________ Date__________ Data Controller________________________

Firing Lane_________ [Rifle #_________ DVS #__________]

DVS *Above* Dry Fire Table (page 1 of 2)

DVS BRM7T1 **FPE:** ***50*__ __**	2-12 75	14-24 75	26-36 75m	38-48 175	50-1:00 175	1:02-1:12 175	1:14-1:24 300	1:26-1:36 300	1:38-1:48 300	1:50-2:00 75	2:02-2:12 75	2:14-2:24 75	2:26-2:36 175	2:38-2:48 175	2:50-3:00 175	3:02-3:12 300	3:14-3:24 300	3:26-3:36 300
Position																		
Acquire Target √																		
FOV (W or N) Changed FOV (√)																		

DVS BRM7T2 **FPE:** **50__ __**	2-12 75	14-24 175	26-36 300	38-48 175	50-1:00 75	1:02-1:12 300	1:14-1:24 300	1:26-1:36 75	1:38-1:48 175	1:50-2:00 175	2:02-2:12 300	2:14-2:24 175	2:26-2:36 75	2:38-2:48 300	2:50-3:00 175	3:02-3:12 75	3:14-3:24 300	3:26-3:36 75
Position																		
Acquire Target √																		
FOV (W or N) Changed FOV (√)																		

Tuesday

Practice DVS *Around* Dry Fire Table (page 2 of 2)

DVS BRM7T1 **FPE:** **51__ __**	2-12 75	14-24 75	26-36 75	38-48 175	50-1:00 175	1:02-1:12 175	1:14-1:24 300	1:26-1:36 300	1:38-1:48 300	1:50-2:00 75	2:02-2:12 75	2:14-2:24 75	2:26-2:36 175	2:38-2:48 175	2:50-3:00 175	3:02-3:12 300	3:14-3:24 300	3:26-3:36 300
Position ____																		
Acquire Target(√)																		
FOV (W or N) Changed FOV (√)																		

DVS BRM7T2 **FPE:** **51__ __**	2-12 75	14-24 175	26-36 300	38-48 175	50-1:00 75	1:02-1:12 300	1:14-1:24 300	1:26-1:36 75	1:38-1:48 175	1:50-2:00 175	2:02-2:12 300	2:14-2:24 175	2:26-2:36 75	2:38-2:48 300	2:50-3:00 175	3:02-3:12 75	3:14-3:24 300	3:26-3:36 75
Position ____																		
Acquire Target(√)																		
FOV (W or N) Changed FOV (√)																		

Tuesday

Practice DVS *Above* and *Around* Known Distance (round dispersion)

Soldier's name____________________ Soldier #________ Date__________ Data Controller______________________

Firing Lane__________ [Rifle #__________ DVS #__________]

DVS *Above* Position______________ **FPE Code: 52__ __**	**Number of Rests**	**Elapsed Time (min:sec)**	**FOV (W or N) Changed FOV (√)**
DVS ***Above*** (75m, 5 rds)			
DVS ***Above*** (175m, 10 rds)			
DVS ***Above*** (300m, 5 rds)			

DVS *Around* Position______________ **FPE Code: 53__ __**	**Number of Rests**	**Elapsed Time (min:sec)**	**FOV (W or N) Changed FOV (√)**
DVS ***Around*** (75m, 5 rds)			
DVS ***Around*** (175m, 10 rds)			
DVS ***Around*** (300m, 5 rds)			

Note: *Elapsed time = stopwatch starts when first target rises, stopwatch stops when last shot for last target is fired.*

Tuesday

Practice DVS *Above* and *Around* (Probability of Hit)

Soldier's name____________________ Soldier #________ Date__________ Data Controller____________________

Firing Lane__________ [Rifle #__________ DVS #__________]

		4-14 75	18-28 175	32-52 75, 300	56-1:16 75, 175	1:20-1:40 75, 300	1:44-2:04 175, 300
DVS *Above* **Psn**____________ ______________	Time Fired						
FPE: 54__ __	Rest √						
FOV **(W or N)** Changed FOV (√)							

DVS *Around* **Psn**__________________ _______	Time Fired						
FPE: 55__ __	Rest √						
FOV **(W or N)** Changed FOV (√)							

Shoot Blindly FPE: 00__ __

Wednesday

Target acquisition time with CCO and DVS

Soldier's name______________ Soldier #________ Date________ Data Controller______________
Firing Lane________ [Rifle #________ CCO #________ DVS #________]

CCO Position______________ **FPE Code: 11**__ __	**Acquisition Times per Interval**					
BRM 8 Table 1	2-12 300	14-24 175	26-36 75	38-48 300	50-1:00 175	1:02-1:04 75
CCO (enter time) →						

DVS Position______________ **FPE Code: 24**__ __	**Acquisition Times per Interval**					
BRM 8 Table 1	2-12 300	14-24 175	26-36 75	38-48 300	50-1:00 175	1:02-1:04 75
DVS ***Above*** (enter time) →						
FOV **(W or N)** Changed FOV (√)						

DVS Position______________ **FPE Code: 27**__ __	**Acquisition Times per Interval**					
BRM 8 Table 1	2-12 300	14-24 175	26-36 75	38-48 300	50-1:00 175	1:02-1:04 75
DVS ***Around*** (enter time) →						
FOV **(W or N)** Changed FOV (√)						

Wednesday

Known Distance (round dispersion with CCO and DVS)

Soldier's name____________________ Soldier #________ Date__________ Data Controller__________________
Firing Lane__________ [Rifle #__________ CCO #__________ DVS #__________]

CCO Position____________________ **FPE Code: 12**__ __	**Number of Rests**	**Elapsed Time (min:sec)**
CCO (75m, 5 rds)		
CCO (175m, 10 rds)		
CCO (300m, 5 rds)		

DVS *Above* Position______________ **FPE Code: 25**__ __	**Number of Rests**	**Elapsed Time (min:sec)**	**FOV (W or N)** **Changed FOV (√)**
DVS ***Above*** (75m, 5 rds)			
DVS ***Above*** (175m, 10 rds)			
DVS ***Above*** (300m, 5 rds)			

DVS *Around* Position____________ **FPE Code: 28**__ __	**Number of Rests**	**Elapsed Time (min:sec)**	**FOV (W or N)** **Changed FOV (√)**
DVS ***Around*** (75m, 5 rds)			
DVS ***Around*** (175m, 10 rds)			
DVS ***Around*** (300m, 5 rds)			

Note: *Elapsed time = stopwatch starts when first target rises, stopwatch stops when last shot for last target is fired.*

Wednesday

Practice with TWS dry fire

Soldier's name____________________ Soldier #_______ Date__________ Data Controller____________________

Firing Lane_________ [Rifle #_________ TWS #_________]

TWS *Above* Dry Fire Table (page 1 of 2)

TWS BRM7T1 FPE: 60__ __	2-12 75	14-24 75	26-36 75	38-48 175	50-1:00 175	1:02-1:12 175	1:14-1:24 300	1:26-1:36 300	1:38-1:48 300	1:50-2:00 75	2:02-2:12 75	2:14-2:24 75	2:26-2:36 175	2:38-2:48 175	2:50-3:00 175	3:02-3:12 300	3:14-3:24 300	3:26-3:36 300
Position																		
Acquire Target √																		
Setting (std, Z) Changed zoom(√)																		

TWS BRM7T2 FPE: 60__ __	2-12 75	14-24 175	26-36 300	38-48 175	50-1:00 75	1:02-1:12 300	1:14-1:24 300	1:26-1:36 75	1:38-1:48 175	1:50-2:00 175	2:02-2:12 300	2:14-2:24 175	2:26-2:36 75	2:38-2:48 300	2:50-3:00 175	3:02-3:12 75	3:14-3:24 300	3:26-3:36 75
Position																		
Acquire Target √																		
Setting (std, Z) Changed zoom(√)																		

Wednesday

Practice TWS *Around* Dry Fire Table (page 2 of 2)

TWS BRM7T1 FPE: 61__ __	2-12 75	14-24 75	26-36 75	38-48 175	50-1:00 175	1:02-1:12 175	1:14-1:24 300	1:26-1:36 300	1:38-1:48 300	1:50-2:00 75	2:02-2:12 75	2:14-2:24 75	2:26-2:36 175	2:38-2:48 175	2:50-3:00 175	3:02-3:12 300	3:14-3:24 300	3:26-3:36 300
Position																		
Acquire Target(√)																		
Setting (std, Z) Changed zoom(√)																		

TWS BRM7T2 FPE: 61__ __	2-12 75	14-24 175	26-36 300	38-48 175	50-1:00 75	1:02-1:12 300	1:14-1:24 300	1:26-1:36 75	1:38-1:48 175	1:50-2:00 175	2:02-2:12 300	2:14-2:24 175	2:26-2:36 75	2:38-2:48 300	2:50-3:00 175	3:02-3:12 75	3:14-3:24 300	3:26-3:36 75
Position																		
Acquire Target(√)																		
Setting (std, Z) Changed zoom(√)																		

Wednesday

Practice TWS *Above* and *Around* Known Distance (round dispersion)

Soldier's name____________________ Soldier #________ Date__________ Data Controller____________________

Firing Lane__________ [Rifle #__________ TWS #__________]

TWS *Above* Position______________ **FPE Code: 62**__ __	**Number of Rests**	**Elapsed Time (min:sec)**	**Setting (N or Z)** **Changed zoom(√)**
TWS ***Above*** (75m, 5 rds)			
TWS ***Above*** (175m, 10 rds)			
TWS ***Above*** (300m, 5 rds)			

TWS *Around* Position______________ **FPE Code: 63**__ __	**Number of Rests**	**Elapsed Time (min:sec)**	**Setting (N or Z)** **Changed zoom(√)**
TWS ***Around*** (75m, 5 rds)			
TWS ***Around*** (175m, 10 rds)			
TWS ***Around*** (300m, 5 rds)			

Note: *Elapsed time = stopwatch starts when first target rises, stopwatch stops when last shot for last target is fired.*

Wednesday

Practice TWS *Above* and *Around* (Probability of Hit)

Soldier's name________________ Soldier #________ Date__________ Data Controller____________

Firing Lane__________ [Rifle #__________ TWS #__________]

Firing Condition		4-14 75	18-28 175	32-52 75, 300	56-1:16 75, 175	1:20-1:40 75, 300	1:44-2:04 175, 300
TWS *Above* **Psn**__________	Time Fired						
FPE: 64__ __	Rest √						
Setting **(std, Z)** Changed zoom(√)							

TWS *Around* **Psn**__________	Time Fired						
FPE: 65__ __	Rest √						
Setting **(std, Z)** Changed zoom(√)							

Wednesday

Target acquisition time with TWS

Soldier's name________________ Soldier #______ Date_______ Data Controller________________

Firing Lane_______ [Rifle #_______ TWS #_______]

TWS Direct View Baseline Position___ FPE Code: 31__ __	**Acquisition Times per Interval**					
BRM 8 Table 1	2-12 300	14-24 175	26-36 75	38-48 300	50-1:00 175	1:02-1:04 75
TWS Baseline (enter time) →						
Setting (std, Z) Changed zoom(√)						

TWS *Above* Position________ FPE Code: 44__ __	**Acquisition Times per Interval**					
BRM 8 Table 1	2-12 300	14-24 175	26-36 75	38-48 300	50-1:00 175	1:02-1:04 75
TWS ***Above*** (enter time) →						
Setting (std, Z) Changed zoom(√)						

TWS *Around* Position________ FPE Code: 47__ __	**Acquisition Times per Interval**					
BRM 8 Table 1	2-12 300	14-24 175	26-36 75	38-48 300	50-1:00 175	1:02-1:04 75
TWS ***Around*** (enter time) →						
Setting (std, Z) Changed zoom(√)						

Thursday

Pop Up Targets: Probability of Hit with CCO and DVS

Soldier's name____________________ Soldier #________ Date__________ Data Controller______________________

Firing Lane__________ [Rifle #__________ CCO #__________ DVS #__________]

		4-14 175m	18-38 75/ 300	42 – 1:02 75/ 175	1:06- 1:16 300	1:20- 1:40 75/175	1:44- 2:04 175/ 300	2:08- 2:28 75/ 175	2:32- 2:52 175/ 300	2:56- 3:06 75	3:10- 3:30 175/ 300	3:34- 3:54 75/ 175	3:58- 4:18 75/ 300	4:22- 4:32 175
CCO Psn____	Time Fired													
FPE: 13__ __	Rest √													

DVS *Above* Psn______	Time Fired													
FPE: 26__ __	Rest √													
FOV (W or N) Changed FOV (√)														

DVS *Around* Psn______	Time Fired													
FPE: 29__ __	Rest √													
FOV (W or N) Changed FOV (√)														

Thursday

Pop Up Targets: Probability of Hit with CCO and DVS

Soldier's name__________________ Soldier #________ Date__________ Data Controller____________
Firing Lane__________ [Rifle #__________ CCO #__________ DVS #__________]

		2-7 75m	9-16 175	18-29 75/300	31-40 75/175	42-52 75/300	54-1:05 175/300
CCO Psn_____ ________	Time Fired						
FPE: **14__ __**	Rest √						

DVS *Above* **Psn_____** ________	Time Fired						
FPE: **21__ __**	Rest √						
FOV **(W or N)** Changed FOV (√)							

DVS *Around* **Psn_____** ________	Time Fired						
FPE: **22__ __**	Rest √						
FOV **(W or N)** Changed FOV (√)							

Thursday

Known Distance (round dispersion with TWS)

Soldier's name__________________ Soldier #_______ Date__________ Data Controller________________

Firing Lane__________ [Rifle #__________ TWS #__________]

TWS Direct View Baseline Position________ **FPE Code: 32__ __**	**Number of Rests**	**Elapsed Time (min:sec)**	**Setting (N or Z)** **Changed zoom(√)**
TWS Baseline (75m, 5 rds)			
TWS Baseline (175m, 10 rds)			
TWS Baseline (300m, 5 rds)			

TWS *Above* Position________________ **FPE Code: 45__ __**	**Number of Rests**	**Elapsed Time (min:sec)**	**Setting (N or Z)** **Changed zoom(√)**
TWS ***Above*** (75m, 5 rds)			
TWS ***Above*** (175m, 10 rds)			
TWS ***Above*** (300m, 5 rds)			

TWS Reduced *Around* Position__________ **FPE Code: 48__ __**	**Number of Rests**	**Elapsed Time (min:sec)**	**Setting (N or Z)** **Changed zoom(√)**
TWS ***Around*** (75m, 5 rds)			
TWS ***Around*** (175m, 10 rds)			
TWS ***Around*** (300m, 5 rds)			

Note: *Elapsed time = stopwatch starts when first target rises, stopwatch stops when last shot for last target is fired.*

Thursday

Pop Up Targets: Probability of Hit with TWS

Soldier's name____________________ Soldier #________ Date__________ Data Controller____________________

Firing Lane__________ [Rifle #__________ TWS #__________]

		4-14 175m	18- 38 75/ 300	42- 1:02 75/ 175	1:06- 1:16 300	1:20- 1:40 75/ 175	1:44- 2:04 175/ 300	2:08- 2:28 75/ 175	2:32- 2:52 175/ 300	2:56- 3:06 75	3:10- 3:30 175/ 300	3:34- 3:54 75/ 175	3:58- 4:18 75/ 300	4:22- 4:32 175
TWS DV B **Psn**______	Time Fired													
FPE: **33**__ __	Rest √													
(std or Z) Change(√)														

TWS ***Above*** **Psn**______	Time Fired													
FPE: **46**__ __	Rest √													
(std or Z) Change(√)														

TWS ***Around*** **Psn**______	Time Fired													
FPE: 49__ __	Rest √													
(std or Z) Change(√)														

Thursday

Pop Up Targets: Probability of Hit with TWS

Soldier's name_____________________ Soldier #_______ Date_________ Data Controller____________
Firing Lane__________ [Rifle #__________ TWS #__________]

		2-7 75m	9-16 175	18-29 75/300	31-40 75/175	42-52 75/300	54-1:05 175/300
TWS DV B **Psn_____**	Time Fired						
FPE: **34__ __**	Rest √						
(std, Z) Changed zoom(√)							

TWS *Above* **Psn_____**	Time Fired						
FPE: **41__ __**	Rest √						
(std, Z) Changed zoom(√)							

TWS *Around* **Psn_____**	Time Fired						
FPE: **42__ __**	Rest √						
(std, Z) Changed?							

Appendix C

Weekly Schedule

Day 1 (0800 to 1700-1830)

Train on LW system, DVS, and reduced exposure firing positions
Zero/boresight DVS and CCO
Practice fire with DVS – DVS reduced exposure positions (above and around a barricade)
- Target acquisition - Dry-fire – 18 single exposure targets
  - Above a barricade position with DVS
  - Around a barricade position with DVS
- Known distance – Live-fire – 20 rounds
  - Above a barricade position with DVS
  - Around a barricade position with DVS
- Field fire – Live-fire – 10 single and multiple targets, extended exposure
  - Above a barricade position with DVS
  - Around a barricade position with DVS

Test Fire: Unobserved/unaimed fire excursion (10 rounds)

Day 2 (1300 to 2200)

Confirm zero with DVS and CCO
Test Fire with CCO and DVS
- Target Acquisition – Live-fire, 6 single exposure targets
  - CCO
  - Above a barricade position with DVS
  - Around a barricade position with DVS
- Known distance – Live-fire – 20 rounds
  - CCO
  - Above a barricade position with DVS
  - Around a barricade position with DVS

Train on TWS
Zero/boresight TWS
Practice fire with TWS - TWS reduced exposure positions (above and around a barricade)
- Target acquisition - Dry-fire – 18 single exposure targets
  - Above a barricade position with TWS
  - Around a barricade position with TWS
- Known distance – Live-fire – 20 rounds
  - Above a barricade position with TWS
  - Around a barricade position with TWS
- Field fire – Live-fire – 10 single and multiple targets, extended exposure
  - Above a barricade position with TWS
  - Around a barricade position with TWS

Test Fire with TWS
- Target Acquisition – Live-fire, 6 single exposure targets
  - TWS direct view
  - Above a barricade position with TWS
  - Around a barricade position with TWS

Day 3 (1300 to 2110)

Confirm zero with DVS and CCO

Test Fire with DVS and CCO

Field Fire –Live Fire – 22 single and multiple targets with extended exposure times

CCO

Above a barricade position with DVS

Around a barricade position with DVS

Field Fire – Live-fire – 10 single and multiple targets with standard exposure times

CCO

Above a barricade position with DVS

Around a barricade position with DVS

Confirm zero with TWS

Test Fire with TWS

Known distance – Live-fire – 20 rounds

TWS direct view

Above a barricade position with TWS

Around a barricade position with TWS

Field Fire –Live Fire – 22 single and multiple targets with extended exposure times

TWS direct view

Above a barricade position with TWS

Around a barricade position with TWS

Field Fire – Live-fire – 10 single and multiple targets with standard exposure times

TWS direct view

Above a barricade position with TWS

Around a barricade position with TWS

Excursions

Excursion 1, firing around a corner, was conducted on Day 3 of Week 2 after the day firing had been completed.

Excursion 2, sling and no sling comparisons, was conducted on Days 1, 2 and 3 of Week 4 after the day firing had been completed.

The scanning excursion was conducted on Day 3 of Week 4 after the day firing had been completed.

Appendix D

Boresight and Zero Data Collection Forms

CCO

Boresight and Zero CCO

Soldier's name____________________ Soldier #________ Date__________ Data Controller____________________

Firing Lane_________ [Rifle #_________ CCO #_________] CCO Rail Position_________

CCO
FPE Code: 01__ __
2nd FPE Code 02 __ __

Time to Boresight CCO (min:sec). ____________

Number of rounds to zero CCO________________________

CCO windage clicks ________R / L elevation clicks _________U / D Final? YES

CCO windage clicks ________R / L elevation clicks _________U / D Final? YES

CCO windage clicks ________R / L elevation clicks _________U / D Final? YES

CCO windage clicks ________R / L elevation clicks _________U / D Final? YES

CCO windage clicks ________R / L elevation clicks _________U / D Final? YES

CCO windage clicks ________R / L elevation clicks _________U / D Final? YES

CCO windage clicks ________R / L elevation clicks _________U / D Final? YES

Time to zero (min : sec)________

DVS

Boresight and Zero DVS

Soldier's name____________________ Soldier #________ Date__________ Data Controller____________________

Firing Lane__________ [Rifle #__________ DVS #__________]

DVS
FPE Code: 03__ __
2nd FPE Code: 04 __ __

Final DVS WFOV / NFOV boresight setting__________RT / LT __________UP / DN (Reading from the display)

Time to bore sight DVS WFOV/ NFOV (min : sec) ____________

Number of rounds to zero DVS (WFOV/NFOV)______________

DVS Clicks__________RT / LT __________UP / DN Final? Yes?

DVS Clicks__________RT / LT __________UP / DN Final? Yes

DVS Clicks__________RT / LT __________UP / DN Final? Yes

DVS Clicks__________RT / LT __________UP / DN Final? Yes

DVS Clicks__________RT / LT __________UP / DN Final? Yes

DVS Clicks__________RT / LT __________UP / DN Final? Yes

Final DVS WFOV/NFOV Setting ________ RT / LT _______ UP / DN (Reading from the DVS display)

Time to zero DVS WFOV/ NFOV (min : sec) ____________

TWS

Boresight and Zero TWS

Soldier's name____________________ Soldier #________ Date__________ Data Controller__________________

Firing Lane__________ [Rifle #__________ TWS #__________] TWS Rail Position__________

TWS
FPE Code: 05 __ __
2nd FPE Code 06 __ __

Final TWS Boresight Setting ______R/L ______ U/D	(Reading from the TWS display)

Time to Boresight TWS (min:sec) __________________

Number of rounds to zero TWS__________________

TWS clicks __________R / L __________U / D Final? Yes

TWS clicks __________R / L __________U / D Final? Yes

TWS clicks __________R / L __________U / D Final? Yes

TWS clicks __________R / L __________U / D Final? Yes

TWS clicks __________R / L __________U / D Final? Yes

TWS clicks __________R / L __________U / D Final? Yes

TWS clicks __________R / L __________U / D Final? Yes

TWS clicks __________R / L __________U / D Final? Yes

Final TWS Zero Setting ______R/L ______ U/D	(Reading from the TWS display)

Time to zero TWS (min:sec)______________

Appendix E

LOMAH Databases

Deleted Deleted Deleted

FiringDate	FiringTime	UnitId	FirerId	ProgramN	ExerciseN	ShotType	ShotPrope	GroupOrdi	ShotOrdina	PrimarySc	Secondary	Hit/Miss	X	Y	GroupStd	ExerciseSt	ProgramSt
10/7/2003	13.02.35.7	ARI	115	Grouping/2	175m M4	ownShot	[00000000	1	1	1	1	1	-1.96E-01	-4.05E-02	0	0	0
10/7/2003	13.02.38.6	ARI	115	Grouping/2	175m M4	ownShot	[00000000	1	2	1	1	1	-2.19E-01	6.08E-02	0	0	0
10/7/2003	13.02.41.8	ARI	115	Grouping/2	175m M4	ownShot	[00000000	1	3	1	1	1	-1.52E-01	-8.40E-02	0	0	0
10/7/2003	13.05.09.6	ARI	115	Grouping/2	175m M4	ownShot	[00000000	2	4	1	1	1	-3.26E-02	-1.43E-02	0	0	0
10/7/2003	13.05.15.2	ARI	115	Grouping/2	175m M4	ownShot	[00000000	2	5	1	1	1	3.10E-03	2.78E-02	0	0	0
10/7/2003	13.05.20.7	ARI	115	Grouping/2	175m M4	ownShot	[00000000	2	6	1	1	1	-7.30E-02	2.70E-02	0	0	0
10/7/2003	13.06.36.8	ARI	115	Grouping/2	175m M4	ownShot	[00000000	3	7	1	1	1	1.92E-02	1.35E-01	0	0	0
10/7/2003	13.06.41.2	ARI	115	Grouping/2	175m M4	ownShot	[00000000	3	8	1	1	1	4.50E-03	1.80E-01	0	0	0
10/7/2003	13.06.49.5	ARI	115	Grouping/2	175m M4	ownShot	[00000000	3	9	1	1	1	7.18E-02	1.22E-01	1	0	0
10/7/2003	13.10.06.2	ARI	115	Grouping/2	175m M4	ownShot	[00000000	4	10	1	1	1	-1.81E-01	-7.85E-02	0	0	0
10/7/2003	13.10.11.2	ARI	115	Grouping/2	175m M4	ownShot	[00000000	4	11	0	0	0	-3.99E-01	-1.82E-01	0	0	0
10/7/2003	13.10.15.4	ARI	115	Grouping/2	175m M4	ownShot	[00000000	4	12	0	0	0	-3.82E-01	-2.08E-01	0	0	0
10/7/2003	13.13.10.8	ARI	115	Grouping/2	175m M4	ownShot	[00000000	5	13	1	1	1	-3.43E-02	-4.78E-03	0	0	0
10/7/2003	13.13.17.6	ARI	115	Grouping/2	175m M4	ownShot	[00000000	5	14	1	1	1	-6.07E-02	1.31E-01	0	0	0
10/7/2003	13.13.24.1	ARI	115	Grouping/2	175m M4	ownShot	[00000000	5	15	1	1	1	-1.36E-01	-7.79E-03	0	0	0
10/7/2003	13.15.28.8	ARI	115	Grouping/2	175m M4	ownShot	[00000000	6	16	1	1	1	1.84E-02	2.51E-02	0	0	0
10/7/2003	13.15.35.9	ARI	115	Grouping/2	175m M4	ownShot	[00000000	6	17	1	1	1	-4.81E-02	8.55E-02	0	0	0
10/7/2003	13.15.40.1	ARI	115	Grouping/2	175m M4	ownShot	[00000000	6	18	1	1	1	5.63E-02	1.33E-01	1	0	0
10/7/2003	13.08.38.0	ARI	112	Grouping/2	175m M4	ownShot	[00000000	1	1	1	1	1	-5.05E-02	7.30E-02	0	0	0
10/7/2003	13.08.42.1	ARI	112	Grouping/2	175m M4	ownShot	[00000000	1	2	1	1	1	2.71E-02	6.19E-02	0	0	0
10/7/2003	13.08.46.2	ARI	112	Grouping/2	175m M4	ownShot	[00000000	1	3	1	1	1	9.53E-03	1.04E-01	1	0	0
10/7/2003	13.11.49.0	ARI	312	Grouping/2	175m M4	ownShot	[00000000	1	1	0	0	0	-4.30E-01	-5.62E-02	0	0	0
10/7/2003	13.11.53.4	ARI	312	Grouping/2	175m M4	ownShot	[00000000	1	2	1	1	1	-1.98E-01	-6.03E-02	0	0	0
10/7/2003	13.11.57.0	ARI	312	Grouping/2	175m M4	ownShot	[00000000	1	3	0	0	0	-2.74E-01	5.71E-02	0	0	0

Figure E-1. Data fields in the automated LOMAH system spreadsheet data base.

As part of the data control process, each Soldier's data was highlighted with a unique color in order to quickly check the completeness of the database. In Figure E-1, firer #15 was coded gray; firer #12 was coded yellow. This color scheme also made it easier to add required fields to the master database (see Table E-1). For example, the automated LOMAH database shown in Figure E-1 did not include a unique field for the soldier's name (only FirerID which represented the experimental condition and the soldier's number) and no fields that uniquely identified the week of firing and the day within each week. These were only three of the variables (fields) that were added to the master database.

Figure E-1 also shows that some fields were deleted from the automated LOMAH database. These fields were linked to scoring of the traditional courses of fire conducted on the LOMAH range and were not relevant to the reduced exposure firing experiment. Additional fields were needed to include data that were not automatically recorded in the LOMAH database (e.g., device used, firing position), as well as to facilitate the statistical analyses.

Table E-1 lists the names of the variables in the master database and presents a short description of eac variable. The zero and boresight data were taken directly from the data collection forms and were maintained in a separate database.

Table E-1
Variables and Descriptions of Variables in the Master Database

Variable Name	Description
FirerID	Four digit number—The first 2-digits are the Exercise Code (ExCode) followed by the 2-digit Soldier Identification (SoldID) number.
Date	Date of the exercise.
Time	The time that the rounds were fired by the soldier.
Week	The week the exercise took place. Weeks 1-4.
Day	Day of the week of the exercise (Tue, Wed, Thur).
ExCode	Exercise Code—First two digits from 'FirerID'
Stage	Stages of the exercises consisting of Zero, Test, Practice, and Excursions with 'Continue xx' for continuing a previous Zero (xx represents the number of the continued Zero stage.
REFEx	BRM (Basic Rifle Marksmanship) scenarios denoting number of rounds and target presentation.
SoldID	Unique soldier identification number represented by the last 2-digits of the 'FirerID'.
SName	Soldier's Last Name
ProgName	Program Name—BRM period and experimenter identifier codes
ExName	Exercise Name—LOMAH-assigned name for each exercise.
Device	Visual device used on weapon for scenario (**CCO**-Close Combat Optic, **TWS**-Thermal Weapon Sight, **DVS**-Daylight Video Sight)
DeviceCd	Specific device (sight) code denoting exact implementation of device (sight) and firing from either above or around a barricade
Position	Based on position chosen by individual soldier and device utilized – general description
FOV	Field of View: DVS-Wide (W) or Narrow (N); TWS-Standard (Std) or Zoom
Lane	Live Fire range lane # that soldier fired from. Only 2-3 lanes were used, some firers fired on the same lanes – but at different times.
ShotType	LOMAH designation-not relevant —Used as a check if different than 'ownShot'.
ShotOrd	Shot Order—Denotes the order in which shots were fired and total rounds fired. If the scenario had 6 rounds, the ShotOrd variable starts with "1" and ends with "6." When malfunctions occurred, etc., the last sequence or order number will not necessarily reflect the total number of targets in the scenario. With KD, the 75m targets are numbered 1-5, the 175m 1-10 and the 300m targets 1-5.
Range	Distance each target was from the firer (75m, 175m, 300m)
Hit/Miss	1 = Hitting anywhere on the target 0 = No hit of the target
HitCode	1 = Hitting anywhere on the target 0 = No hit of target, but within LOMAH detection area MISS = No hit of the target, shot beyond LOMAH detection area No-fire = No shot fired or detectable in LOMAH system-from data controller record.

Table E-1 cont'd

Variable Name	Description
X	Coordinate of shot location on or off target in fractions of a meter—Windage (0.5521= ½ meter or 55 cm).
Y*	Coordinate of shot location on or off target in fractions of a meter—Elevation (0.5521= ½ meter or 55 cm)
	Note. X and Y coordinates exist only when a round was within the LOMAH detection zone. Therefore there are no coordinates when the hit code is MISS or No-fire. Also in a very few instances (due to miscodes by the data controller) we had to insert hit results by hand. There are no X Y coordinates for these data either.
RMD	Radial Miss Distance: -Distance from center of mass of target to shot position using Pythagorean formula [$a^2 + b^2 = c^2$ or SQRT (X^2 + Y^2)]
Comments	

Appendix F

Data Tables

Table F-1
Summary of Percentage of Targets Detected for all Scenarios

Scenario	Day Fire		
	CCO	DVS Above	DVS Around
Acquisition	99%	99%	98%
22-Target Field Fire Extended Times	97%	98%	98%
10-Target Field Fire Standard Times	99%	94%	96%
	Night Fire		
	TWS Direct	TWS Above	TWS Around
Acquisition	95%	96%	91%
22-Target Field Fire Extended Times	99%	99%	98%
10-Target Field Fire Standard Times	99%	92%	98%

Table F-2
Target Detection Rates in the Field Fire Test Scenarios

Sight-Position	22-Target Field Fire Scenario (Extended times)			10-Target Field Fire Scenario (Standard times)		
	Distance to Target			Distance to Target		
	75m	175m	300m	75m	175m	300m
CCO	106 of 106 (100%)	137 of 137 (100%)	76 of 87 (87%)	61 of 62 (98%)	43 of 44 (98%)	44 of 44 (100%)
DVS Above	111 of 111 (100%)	129 of 131 (98%)	80 of 84 (95%)	68 of 68 (100%)	41 of 44 (93%)	29 of 35 (83%)
DVS Around	114 of 114 (100%)	134 of 135 (99%)	77 of 81 (95%)	65 of 65 (100%)	42 of 43 (98%)	37 of 42 (88%)
TWS Direct	124 of 124 (100%)	150 of 151 (99%)	99 of 99 (100%)	71 of 72 (99%)	50 of 50 (100%)	47 of 48 (98%)
TWS Above	125 of 126 (99%)	156 of 157 (99%)	91 of 91 (100%)	70of 75 (93%)	47 of 51 (92%)	35 of 39 (90%)
TWS Around	127 of 127 (100%)	153 of 156 (98%)	85 of 87 (98%)	72 of 72 (100%)	49 of 50 (98%)	40 of 42 (95%)

Table F-3
Mean Radial Miss Distance (meters) for Hits Only

	75m		175m		300m	
	n	RMD	*n*	RMD	*n*	RMD
Known Distance Scenario						
CCO	68	.08	102	.17	36	.21
DVS Above	56	.11	90	.20	27	.19
DVS Around	60	.09	102	.18	23	.18
TWS Direct View	80	.07	154	.17	50	.19
TWS Above	76	.11	111	.18	40	.22
TWS Around	68	.09	118	.17	20	.30
22-Target Field Fire Scenario with Extended Times						
CCO	99	.10	121	.15	51	.21
DVS Above	90	.13	84	.20	30	.19
DVS Around	95	.14	90	.18	32	.21
TWS Direct View	113	.09	124	.17	52	.21
TWS Above	99	.10	103	.18	36	.24
TWS Around	98	.09	105	.19	30	.22
10-Target Field Fire Scenario with Standard Times						
CCO	58	.09	39	.16	16	.25
DVS Above	50	.12	33	.16	11	.23
DVS Around	54	.12	37	.16	11	.20
TWS Direct View	64	.10	43	.16	12	.18
TWS Above	51	.11	30	.16	11	.20
TWS Around	61	.11	27	.19	7	.22

Note. *n* refers to the number of rounds.

Appendix G

Location of Hits and Misses

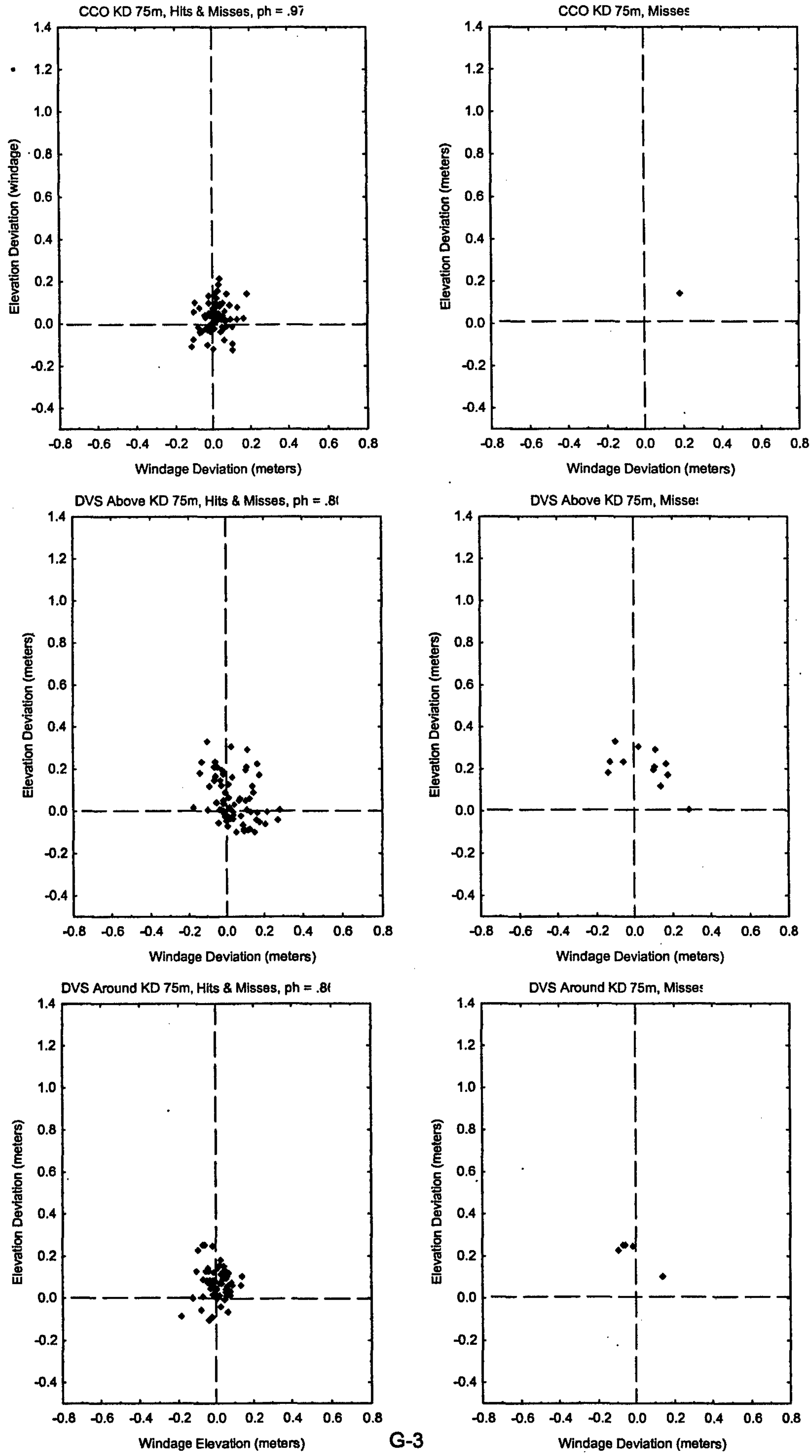
Known Distance Test Scenario

Day Fire and Night Fire

Left-hand column on each page displays hits and misses.

Right-hand column on each page display misses only.

Hits and Misses **Misses**



CCO

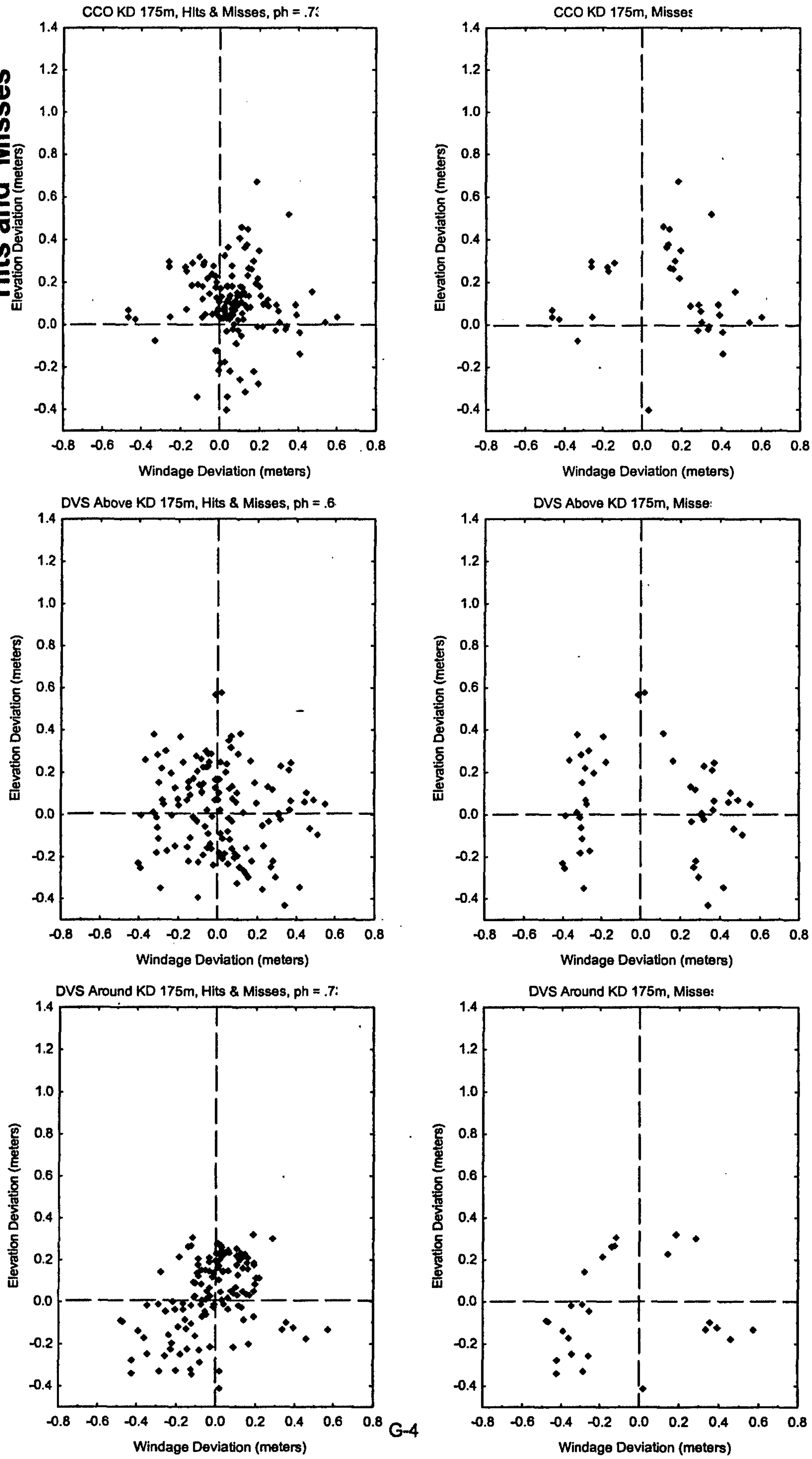
DVS Above

DVS Around

KD 75m

Hits and Misses

Misses

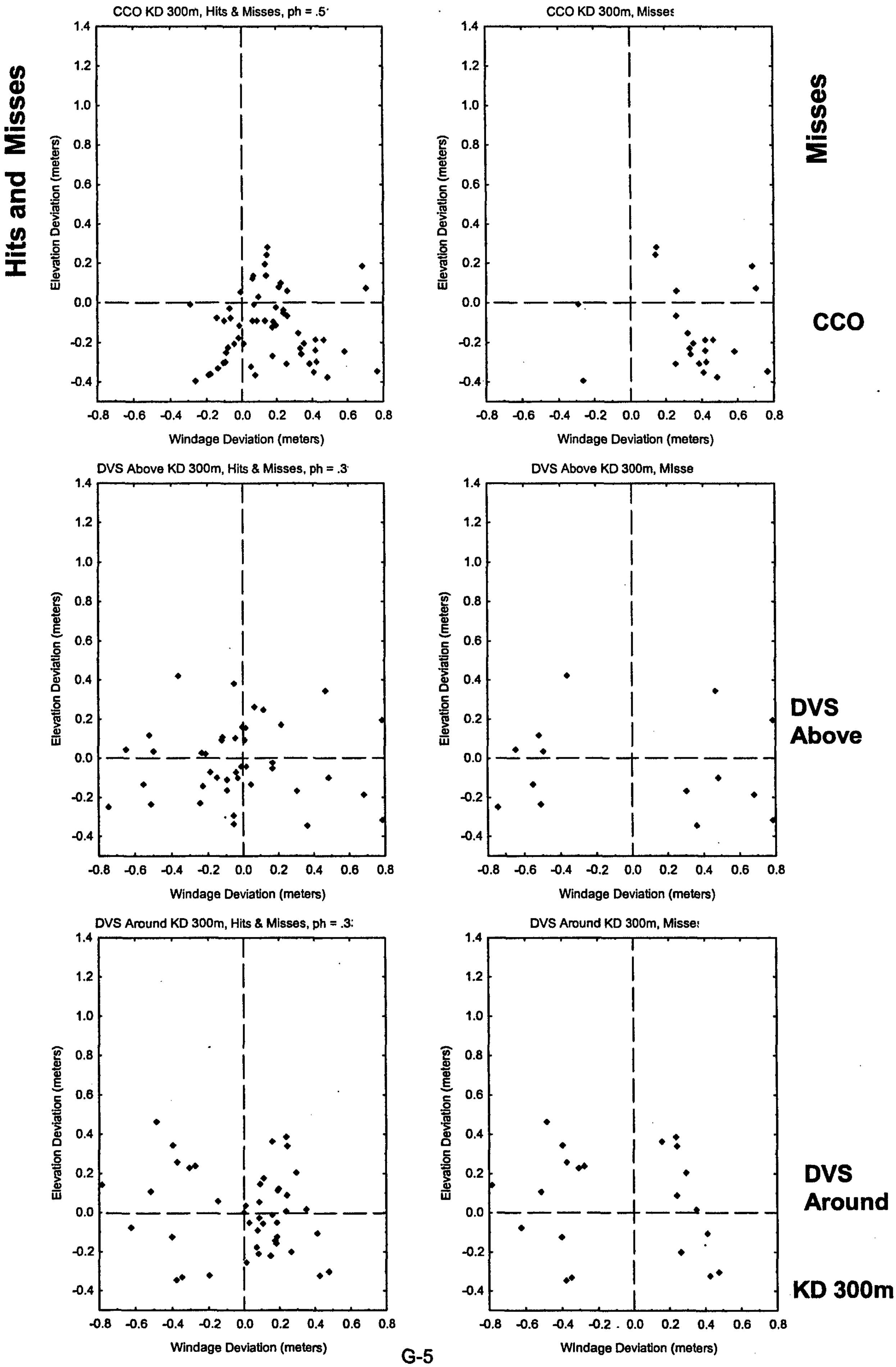


CCO

DVS
Above

DVS
Around

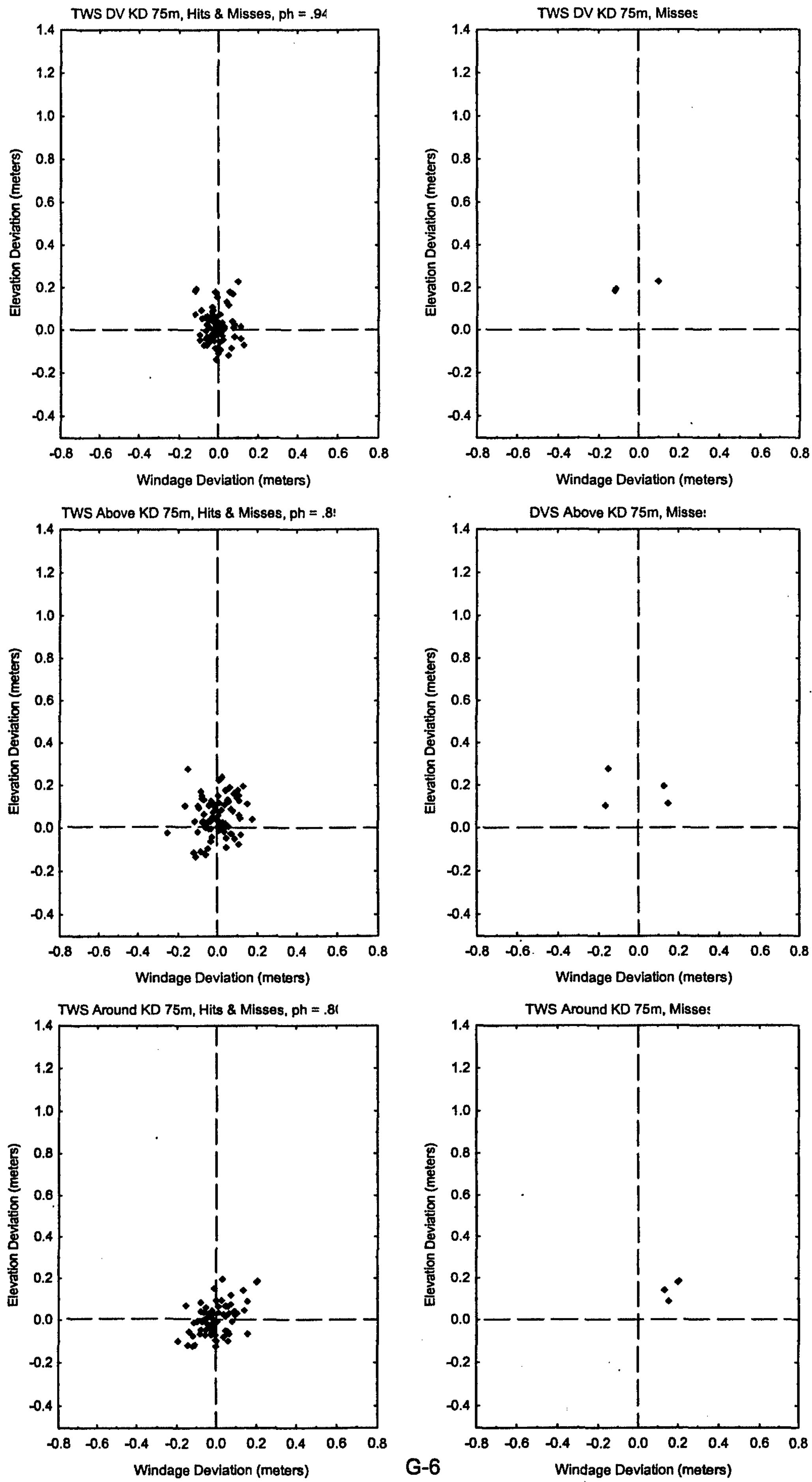
KD 175m



Hits and Misses
Misses
CCO KD 300m, Hits & Misses, ph = .5
CCO KD 300m, Misses
CCO
DVS Above KD 300m, Hits & Misses, ph = .3
DVS Above KD 300m, Misse
DVS Above
DVS Around KD 300m, Hits & Misses, ph = .3
DVS Around KD 300m, Misse
DVS Around
KD 300m
Elevation Deviation (meters)
Windage Deviation (meters)

Hits and Misses

Misses



TWS Direct

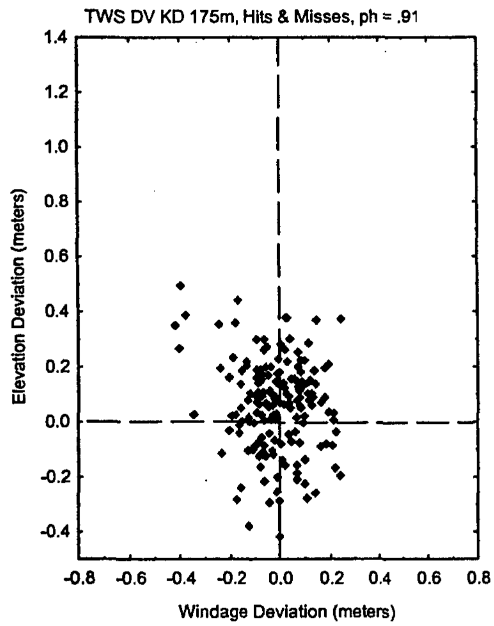
TWS Above

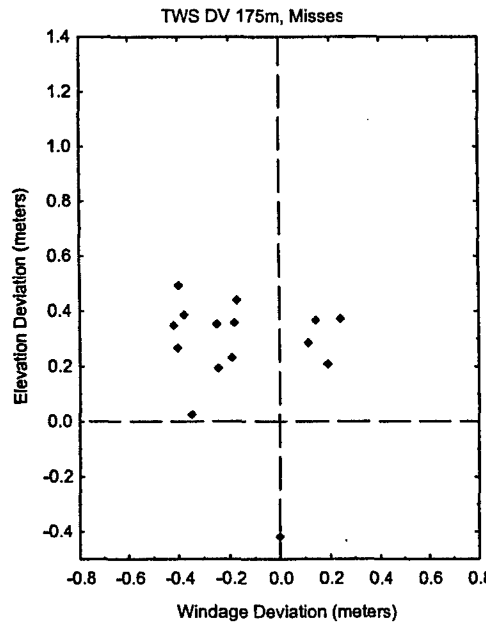
TWS Around

KD 75m

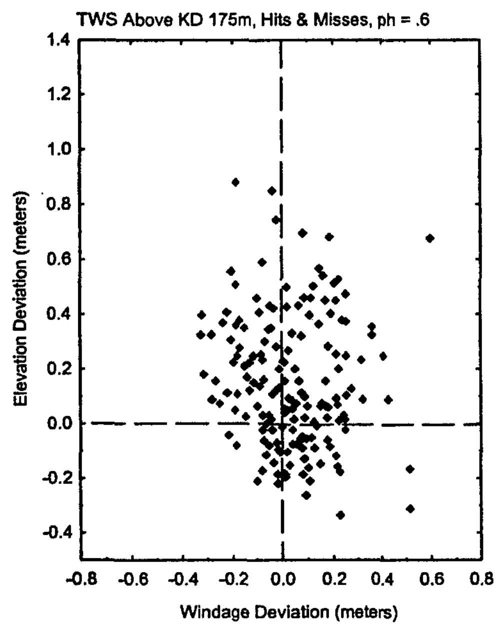
Hits and Misses

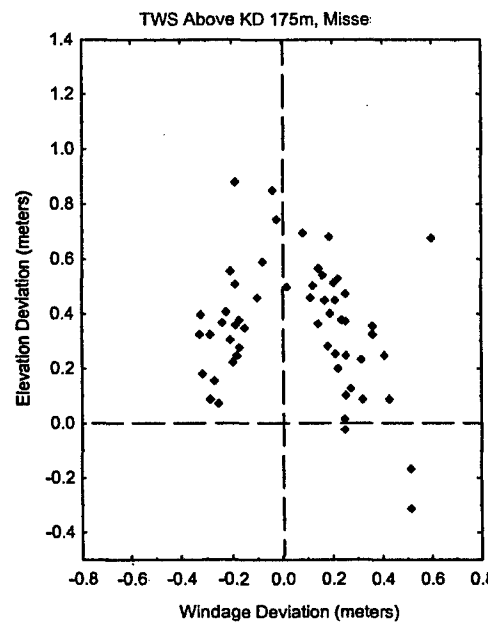
Misses



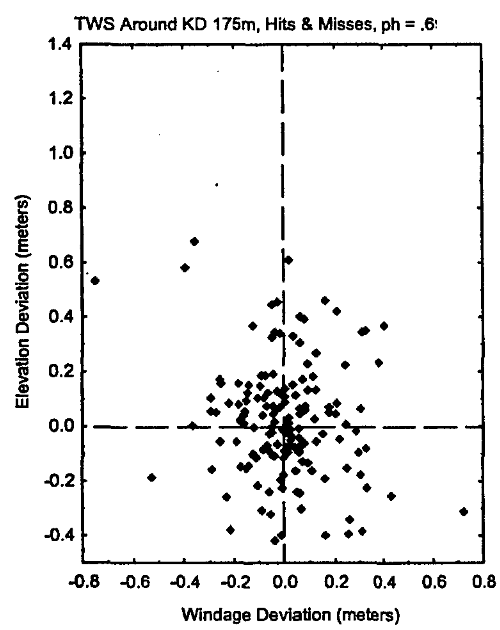


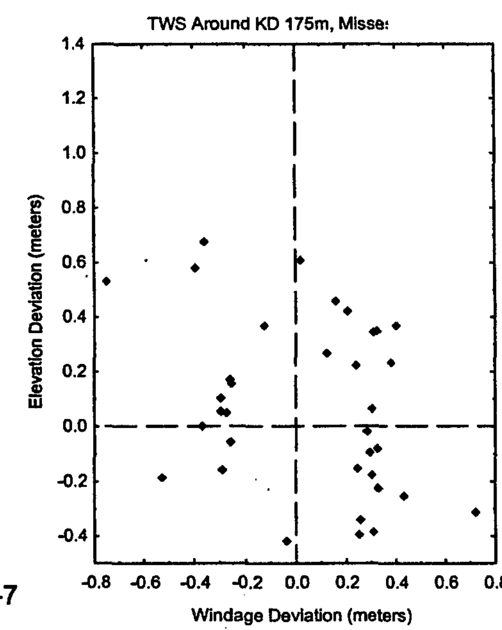
TWS Direct





TWS Above



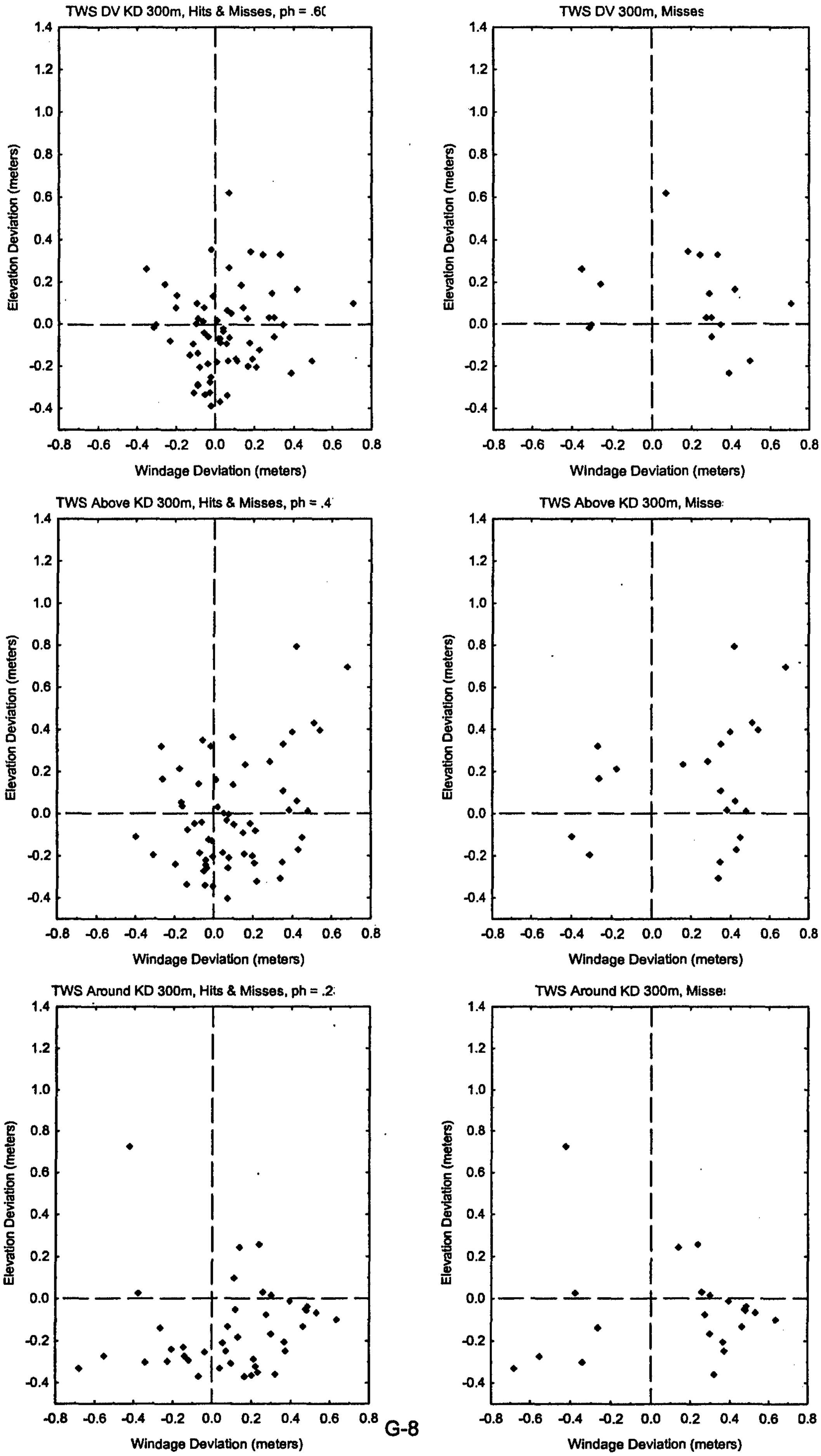


TWS Around

KD 175m

Hits and Misses

Misses



TWS Direct

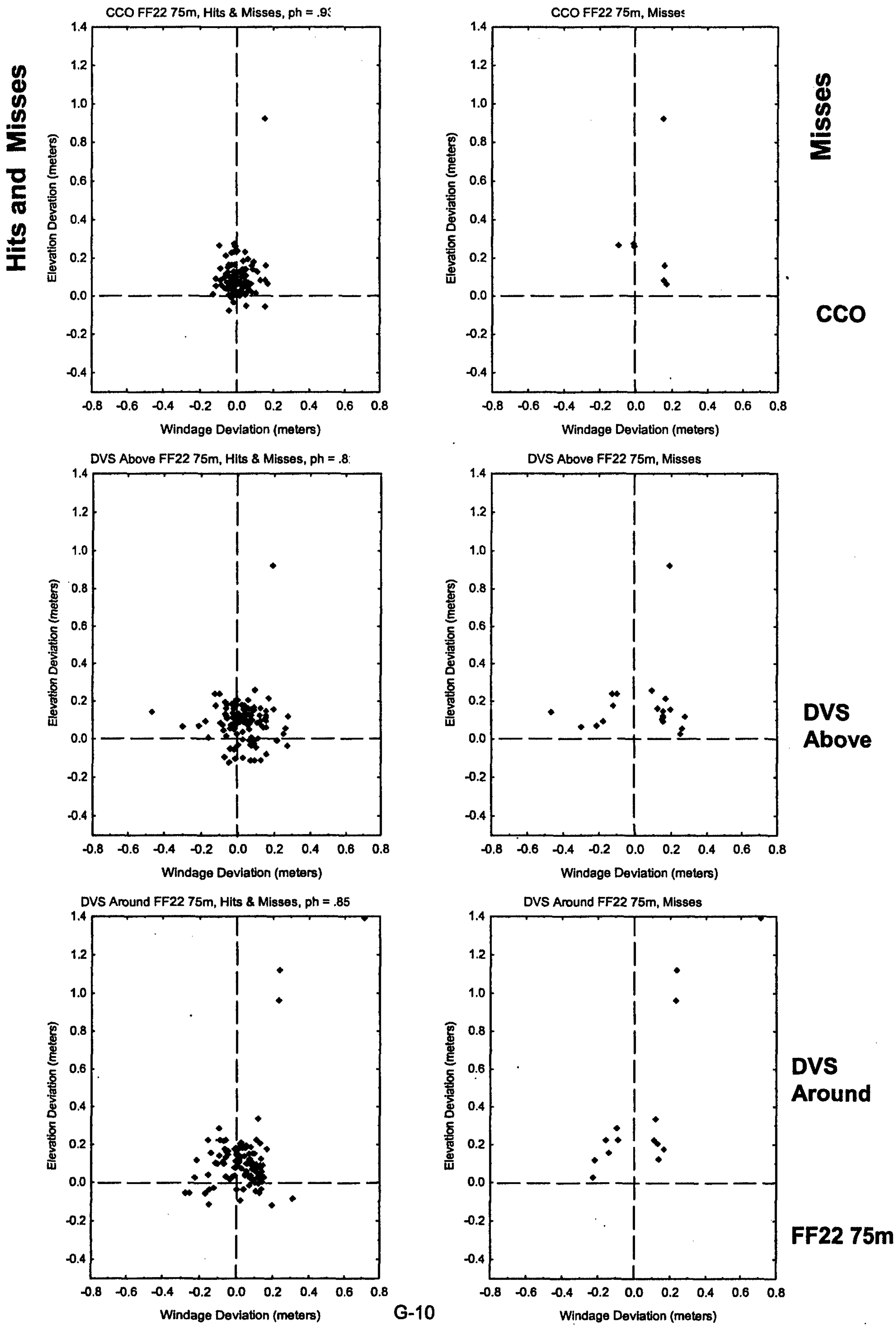
TWS Above

TWS Around

KD 300m

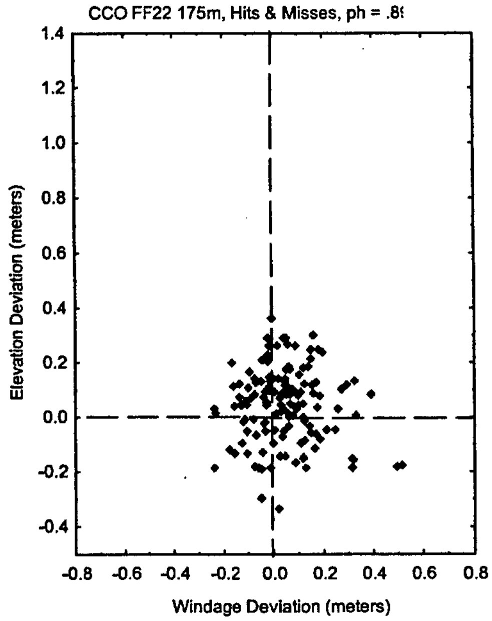
22-Target Field Fire Test Scenario with Extended Exposure Times

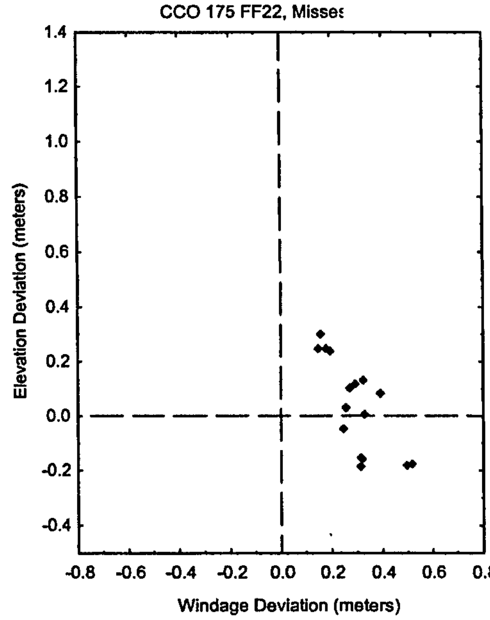
Day Fire and Night Fire


Hits and Misses
Misses
CCO
DVS Above
DVS Around
FF22 75m
CCO FF22 75m, Hits & Misses, ph = .93
CCO FF22 75m, Misses
DVS Above FF22 75m, Hits & Misses, ph = .8
DVS Above FF22 75m, Misses
DVS Around FF22 75m, Hits & Misses, ph = .85
DVS Around FF22 75m, Misses
Elevation Deviation (meters)
Windage Deviation (meters)

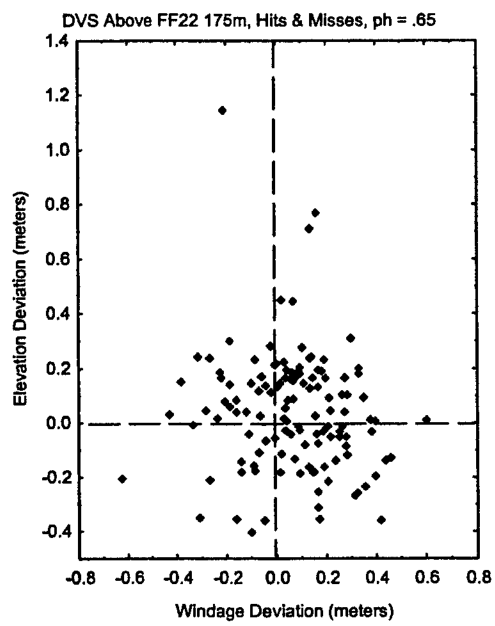
Hits and Misses

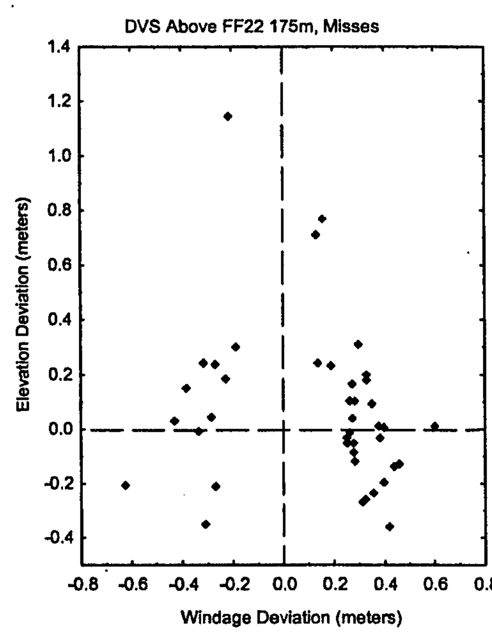
Misses



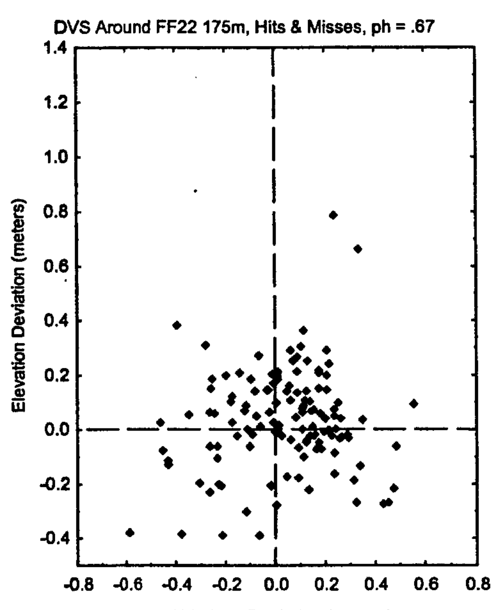


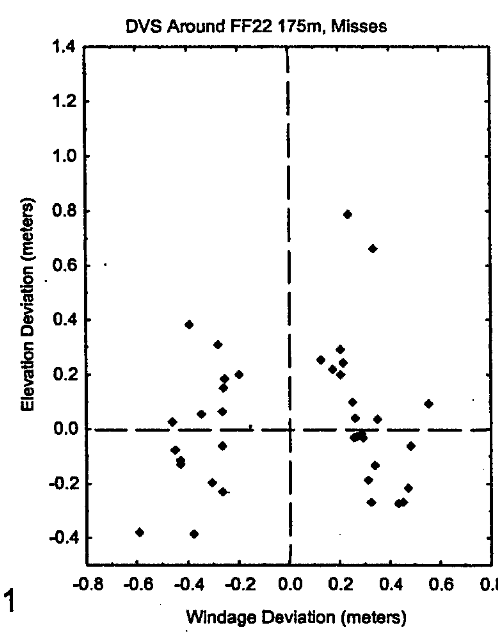
CCO





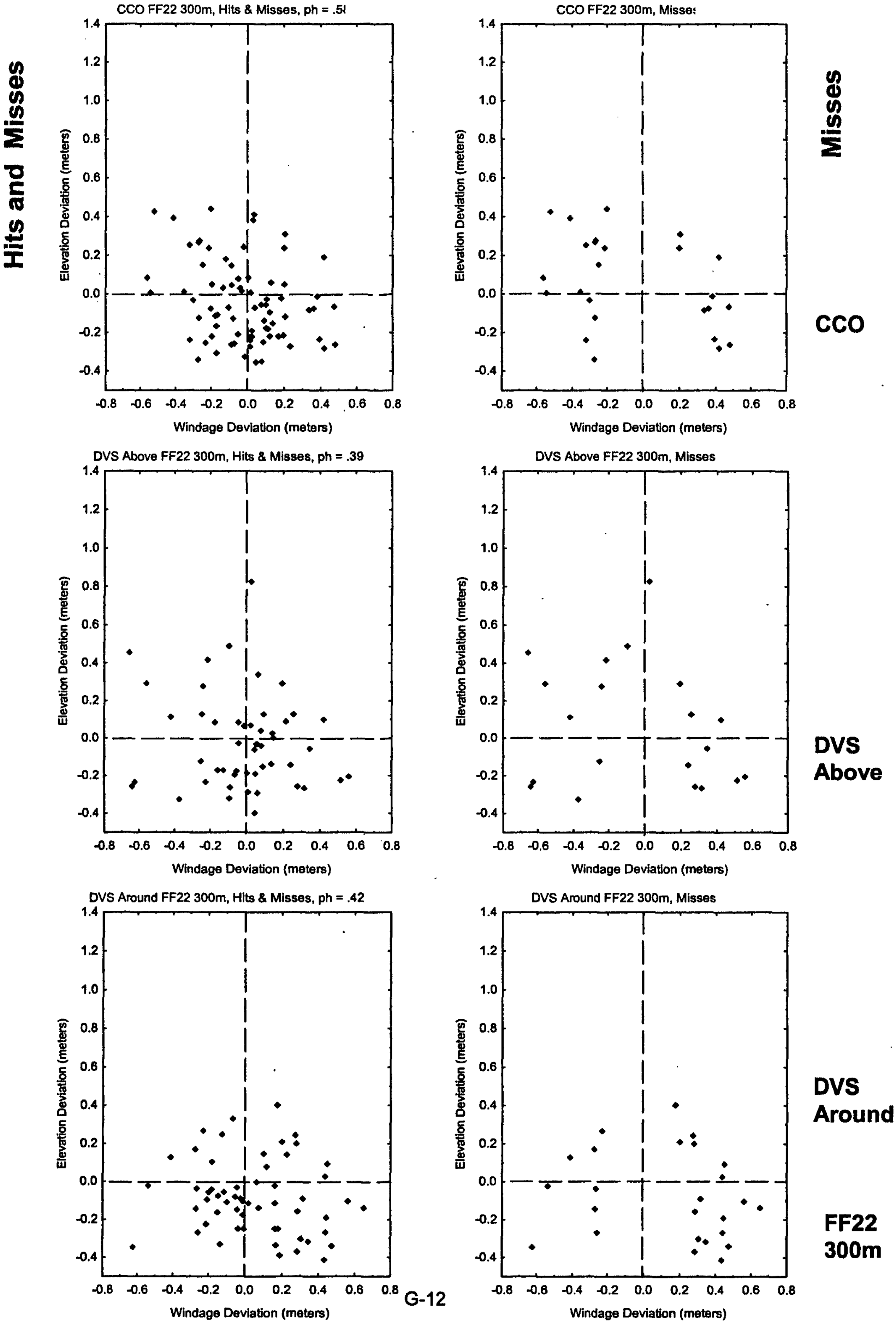
DVS Above

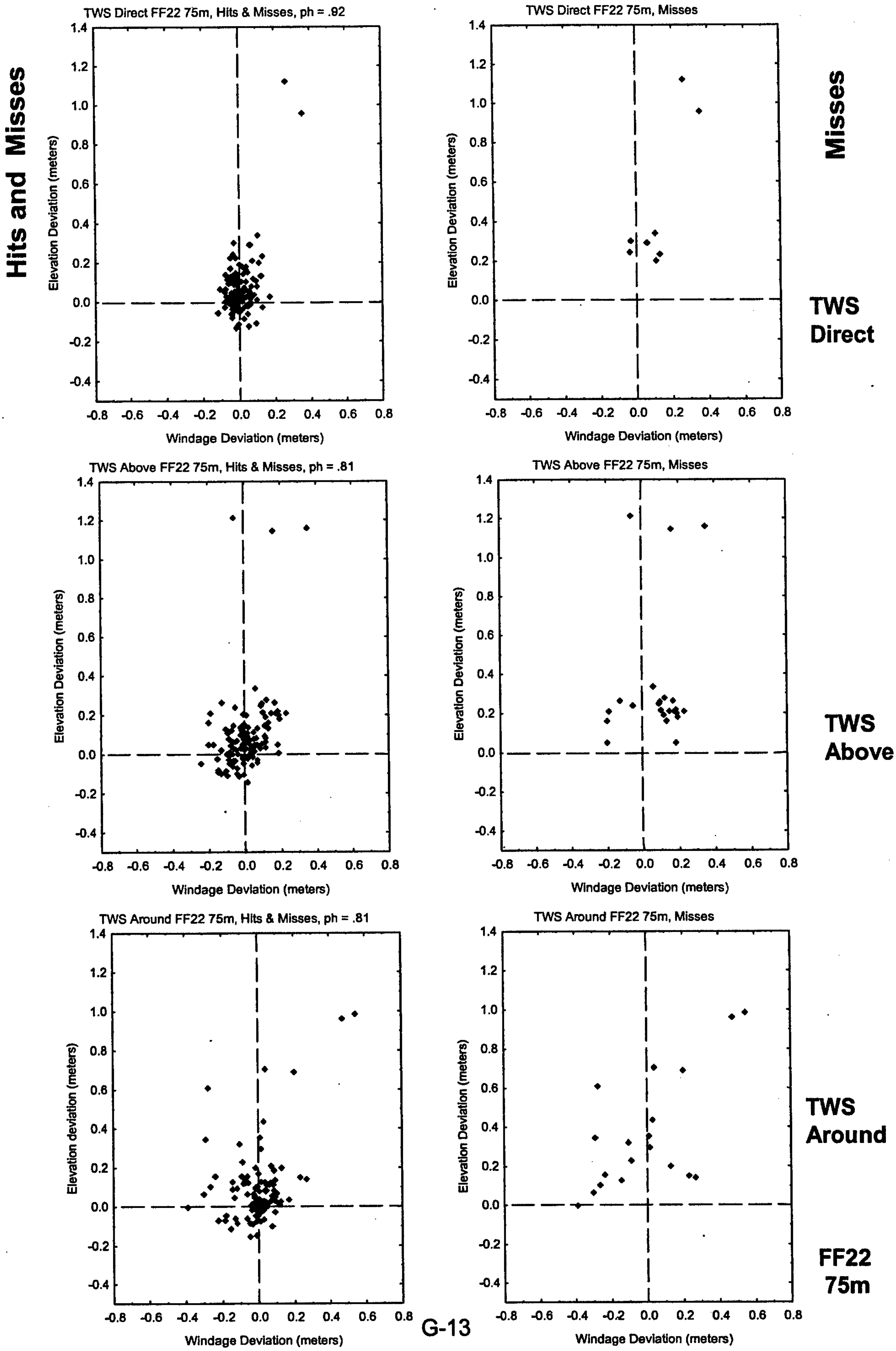




DVS Around

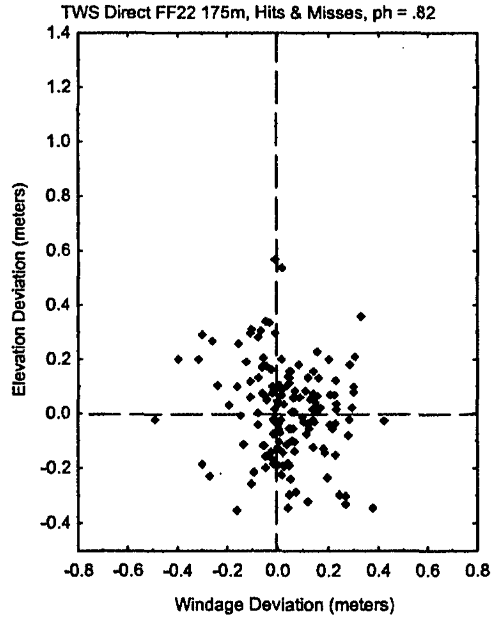
FF22 175m

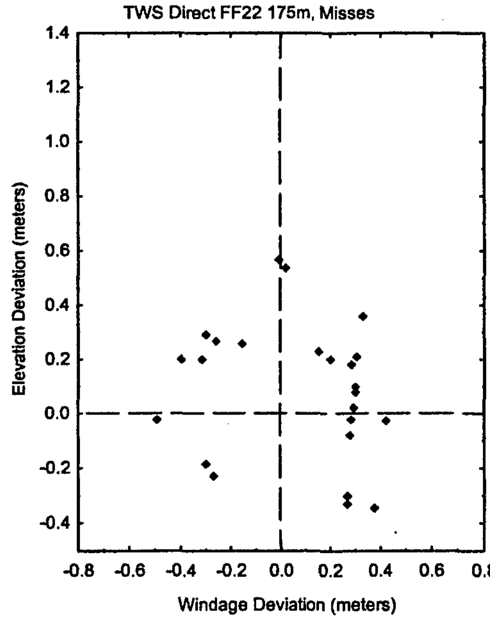

Hits and Misses
Misses
CCO FF22 300m, Hits & Misses, ph = .5
CCO FF22 300m, Misses
CCO
DVS Above FF22 300m, Hits & Misses, ph = .39
DVS Above FF22 300m, Misses
DVS Above
DVS Around FF22 300m, Hits & Misses, ph = .42
DVS Around FF22 300m, Misses
DVS Around
FF22 300m
Elevation Deviation (meters)
Windage Deviation (meters)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8


Hits and Misses
Misses
TWS Direct FF22 75m, Hits & Misses, ph = .92
TWS Direct FF22 75m, Misses
TWS Direct
TWS Above FF22 75m, Hits & Misses, ph = .81
TWS Above FF22 75m, Misses
TWS Above
TWS Around FF22 75m, Hits & Misses, ph = .81
TWS Around FF22 75m, Misses
TWS Around
FF22 75m
Elevation Deviation (meters)
Elevation deviation (meters)
Windage Deviation (meters)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.8
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8

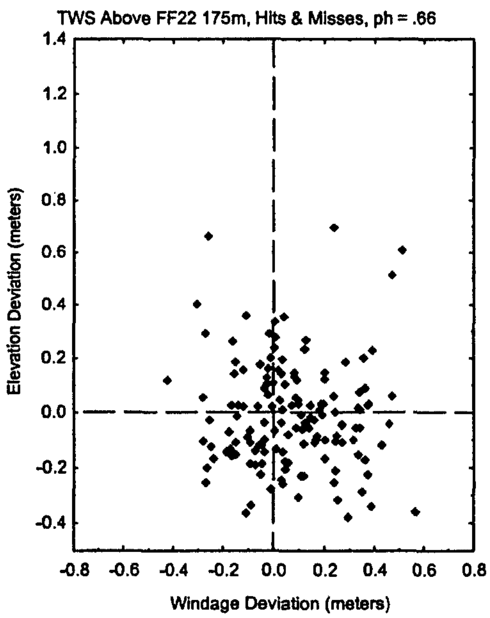
Hits and Misses

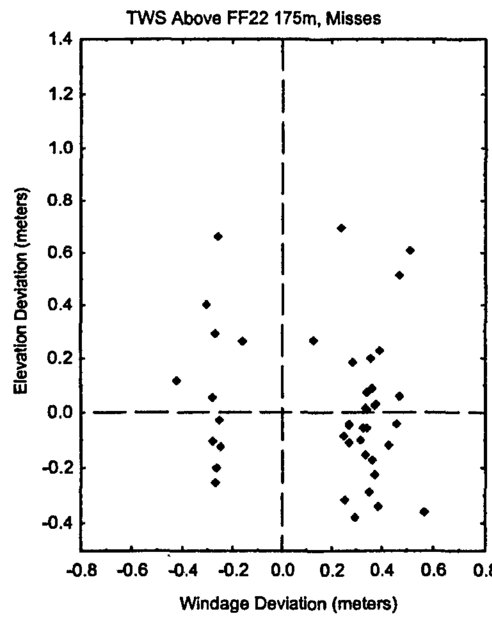
Misses



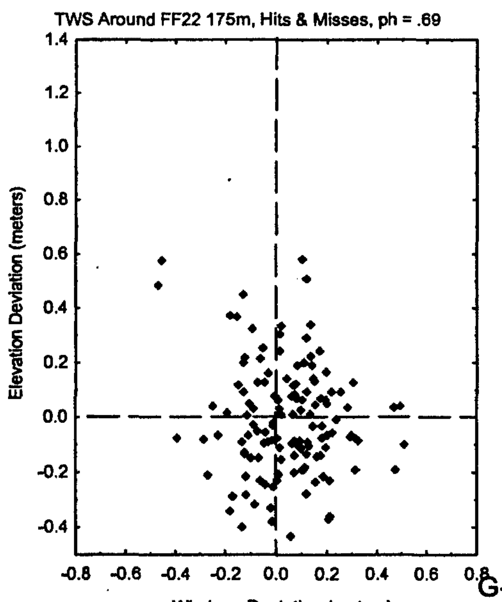


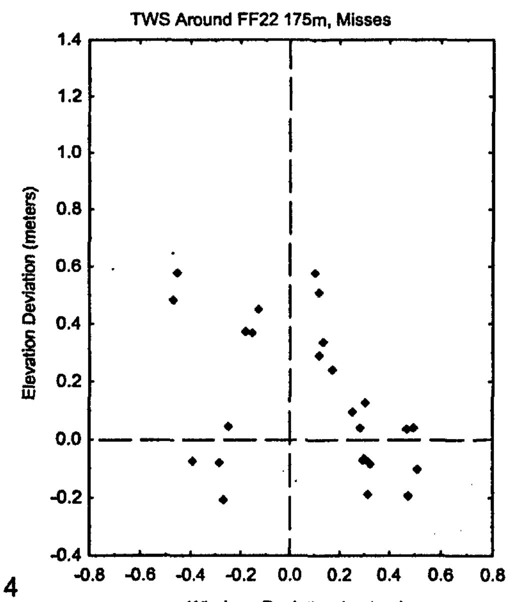
TWS Direct





TWS Above



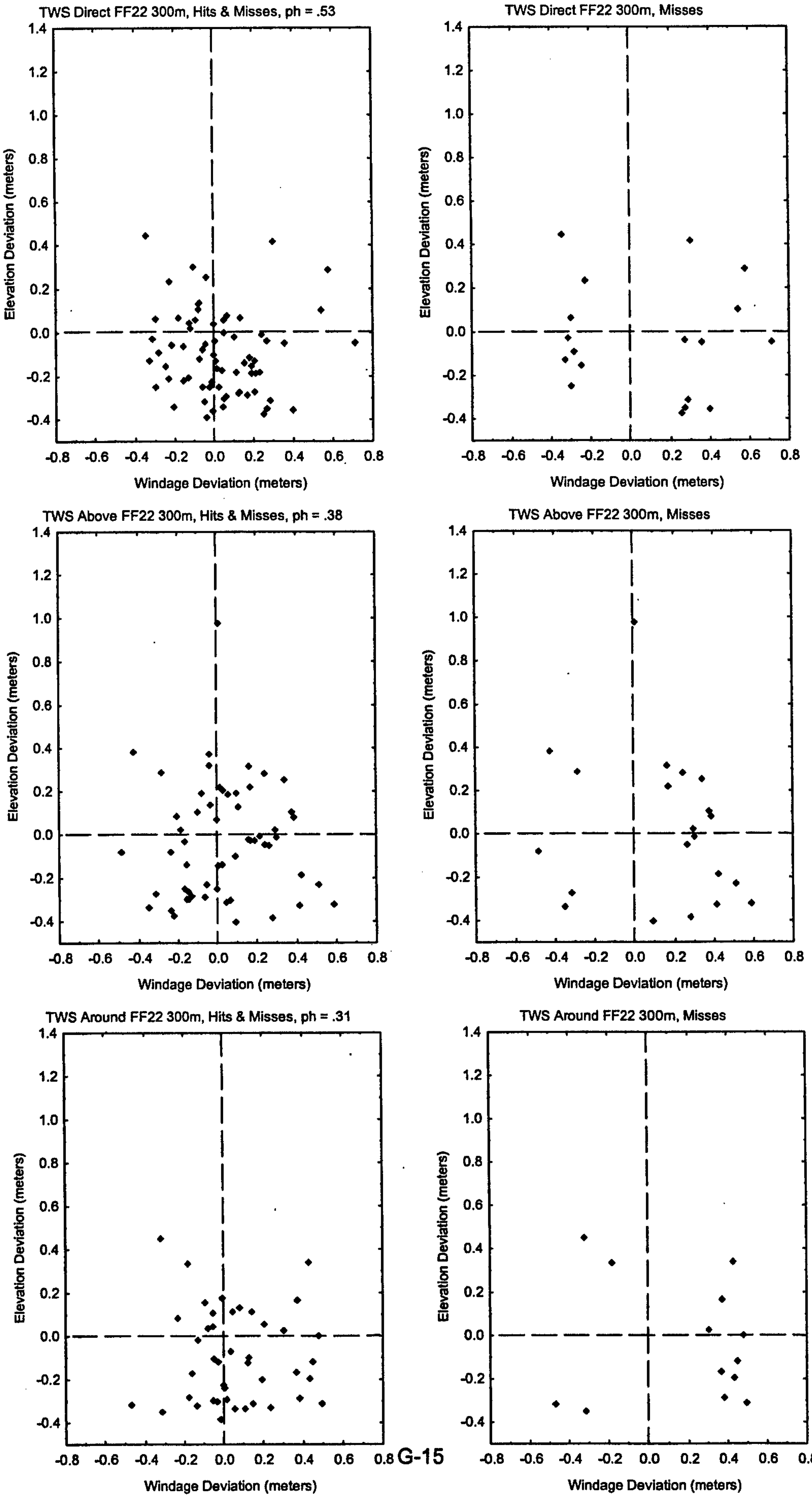


TWS Around

FF22 175m

Hits and Misses

Misses



TWS Direct

TWS Above

TWS Around

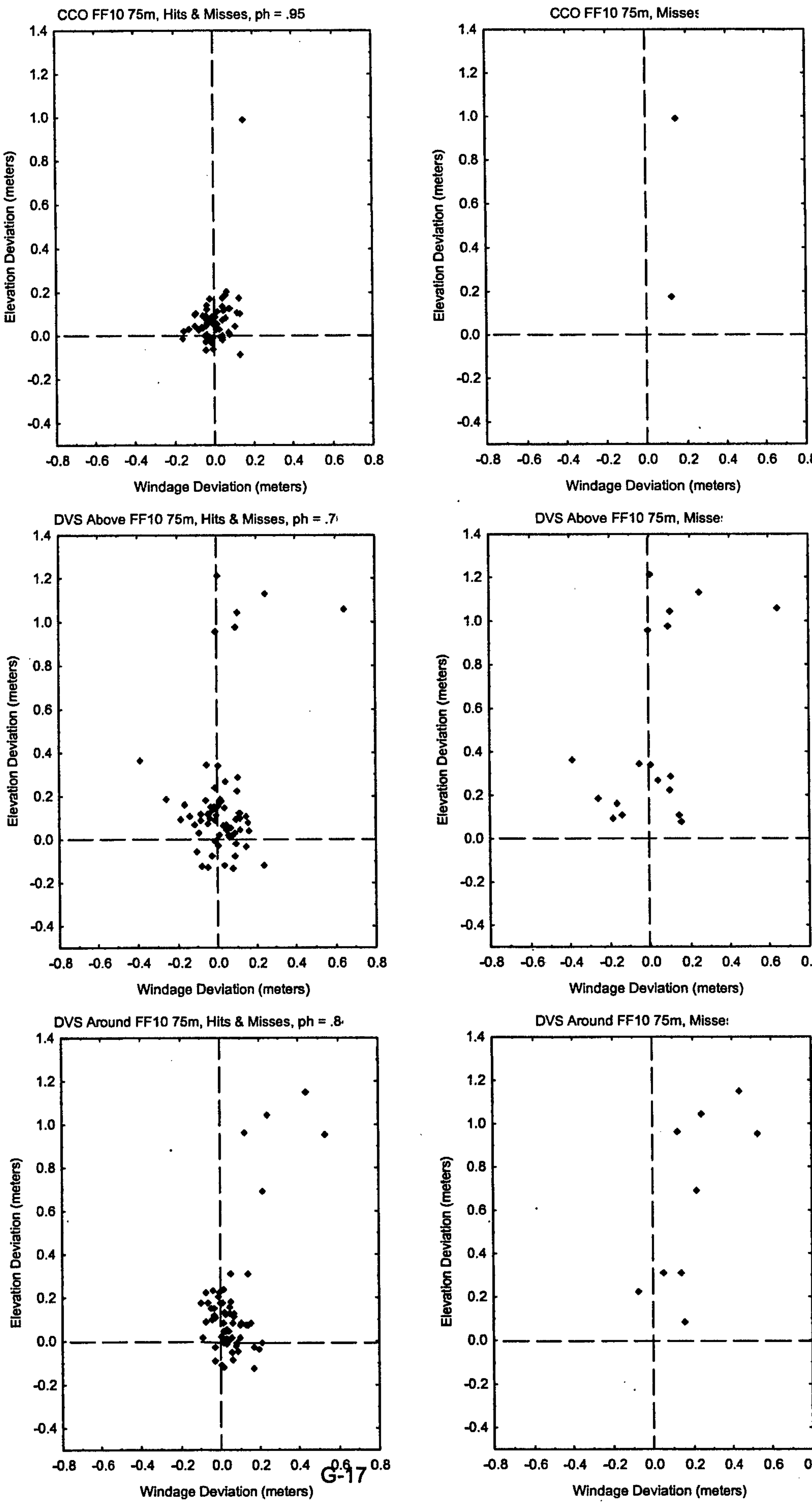
FF22 300m

10-Target Field Fire Test Scenario with Standard Exposure Times

Day Fire and Night Fire

Hits and Misses

Misses



CCO

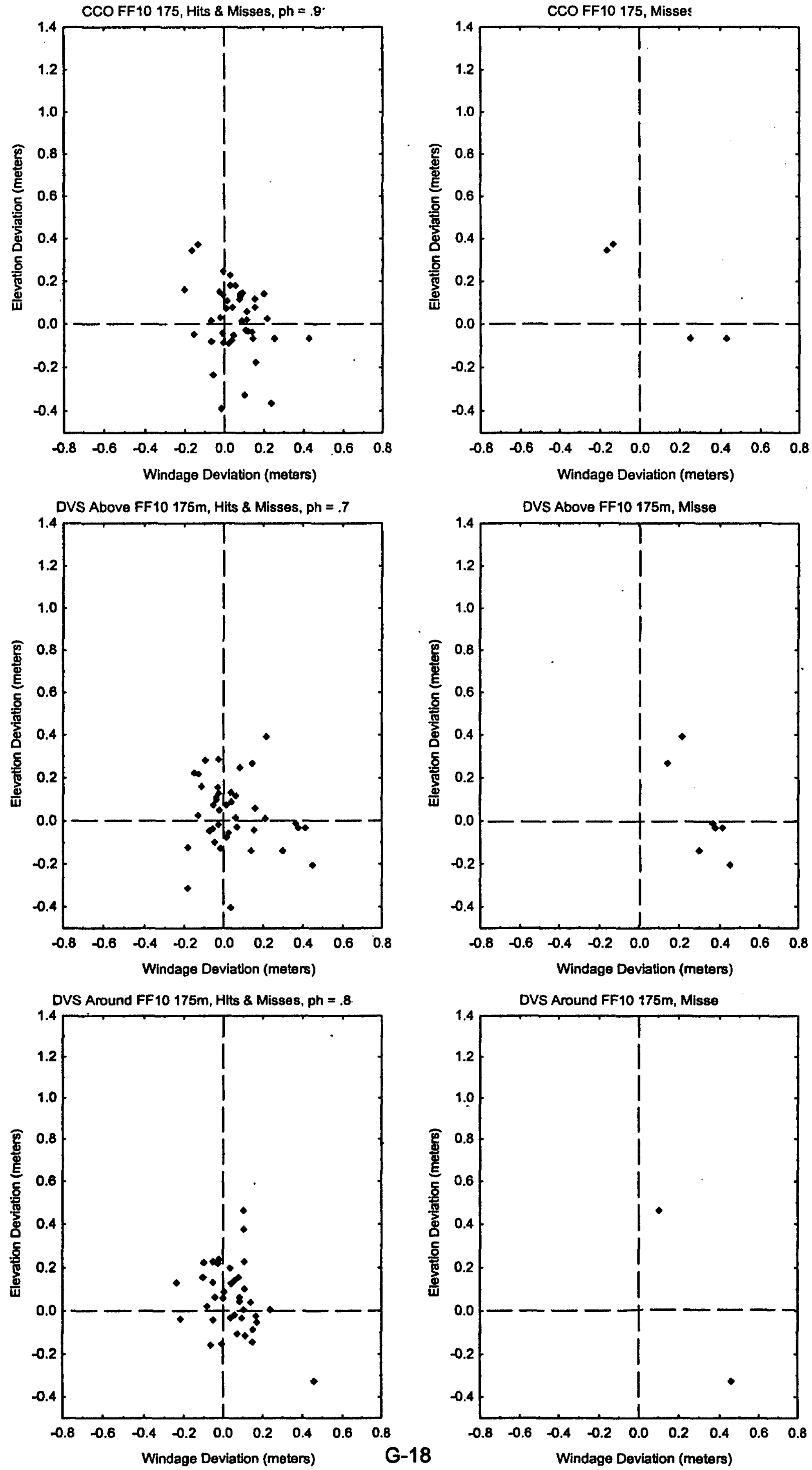
DVS Above

DVS Around

FF10 75m

Hits and Misses

Misses

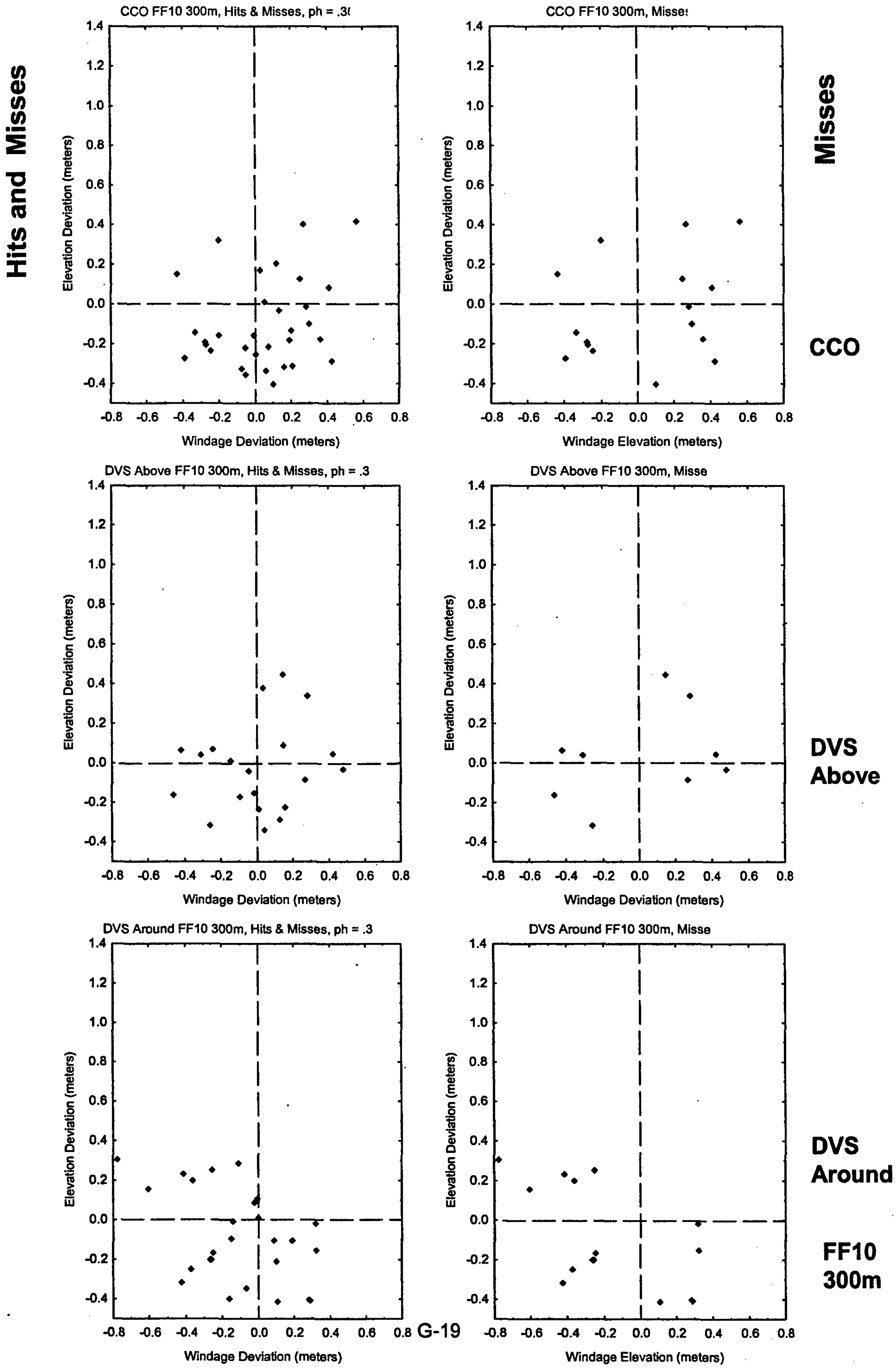


CCO

DVS Above

DVS Around

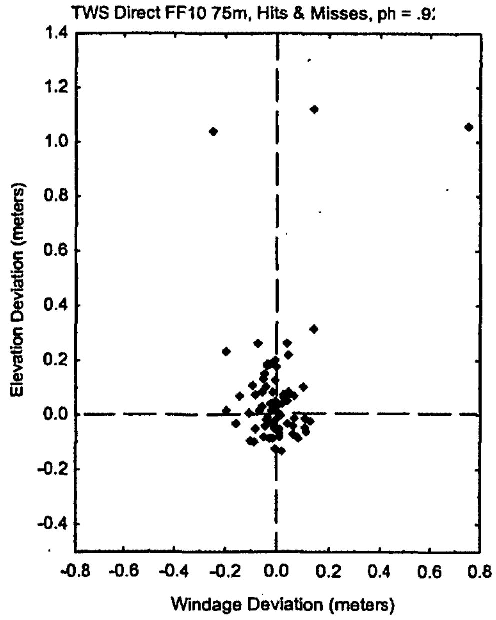
FF10 175m

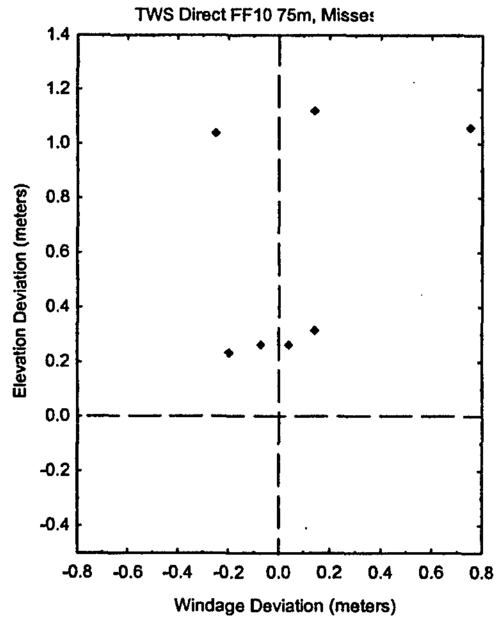


Hits and Misses
Misses
CCO FF10 300m, Hits & Misses, ph = .3(
CCO FF10 300m, Misse:
CCO
DVS Above FF10 300m, Hits & Misses, ph = .3
DVS Above FF10 300m, Misse
DVS Above
DVS Around FF10 300m, Hits & Misses, ph = .3
DVS Around FF10 300m, Misse
DVS Around
FF10 300m
Elevation Deviation (meters)
Windage Deviation (meters)
Windage Elevation (meters)

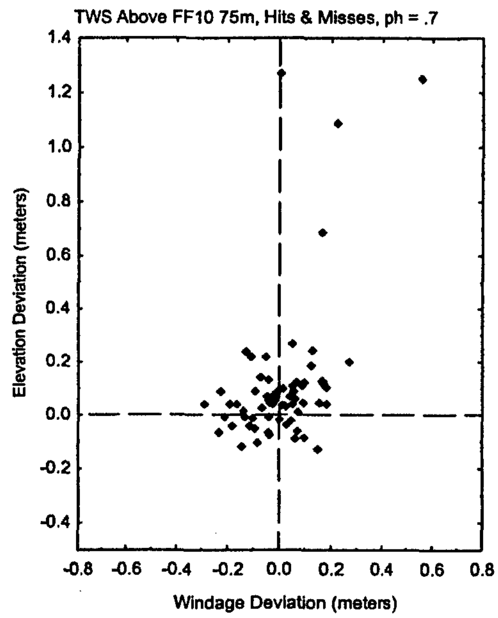
Hits and Misses

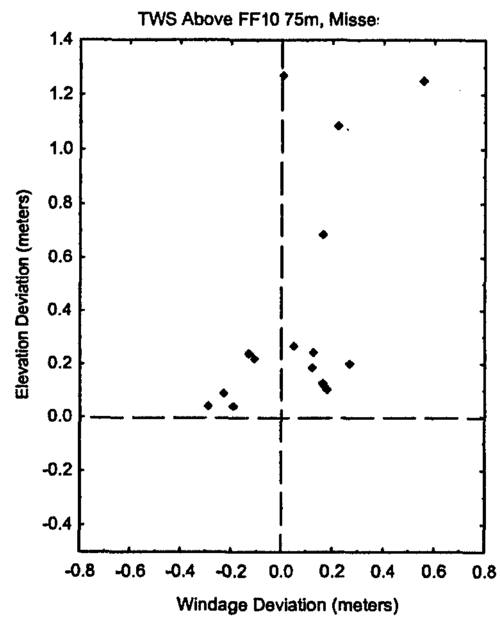
Misses



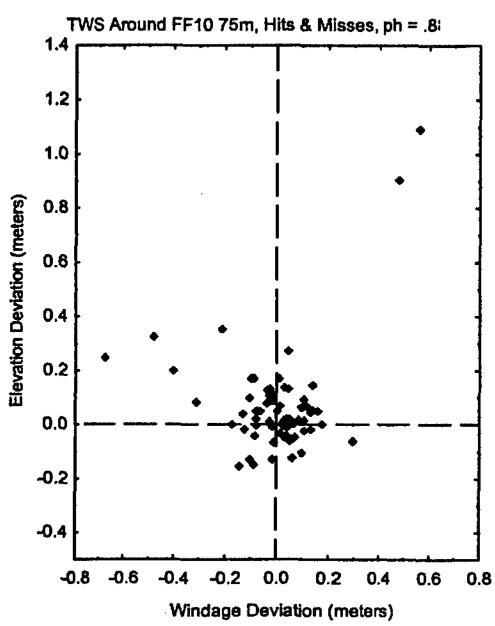


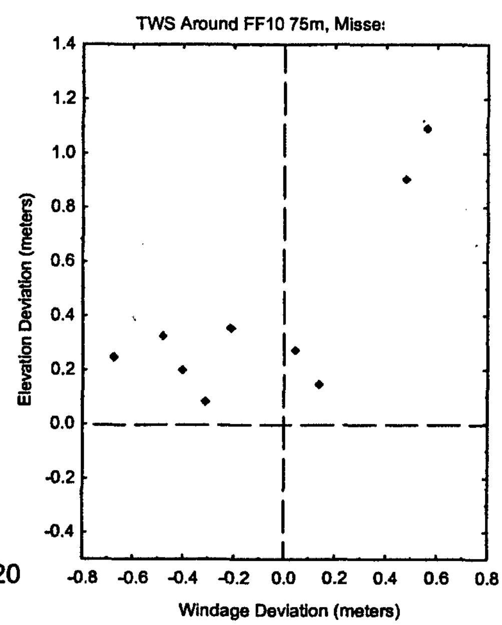
TWS Direct





TWS Above



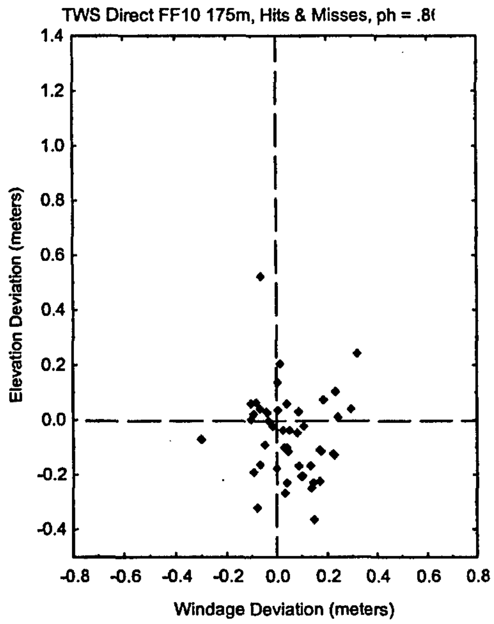


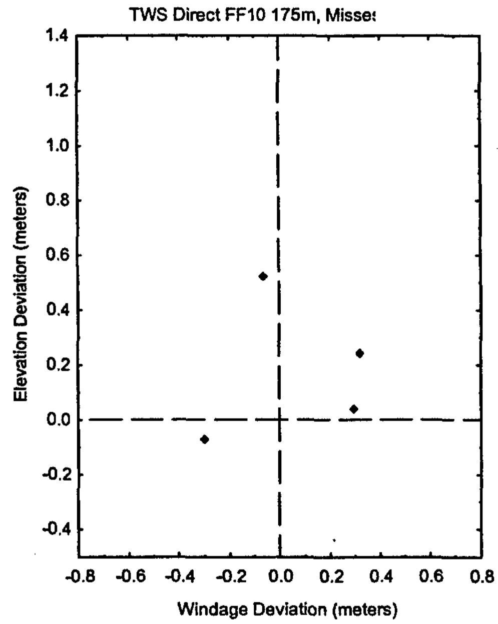
TWS Around

FF10 75m

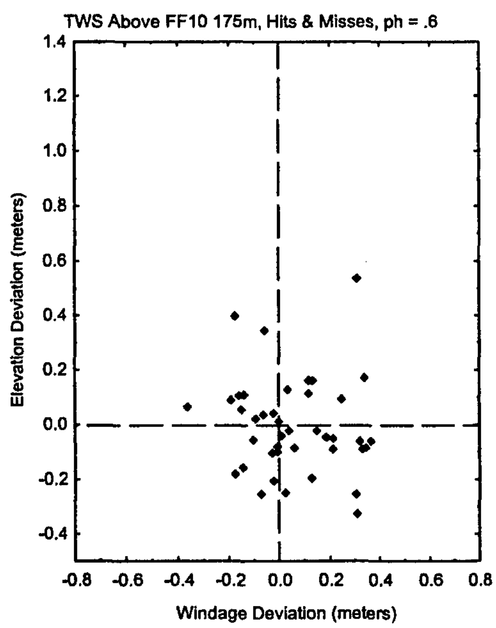
Hits and Misses **Misses**

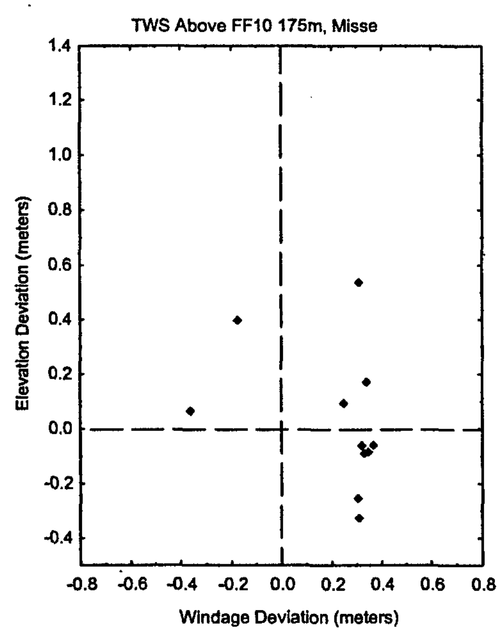
TWS Direct





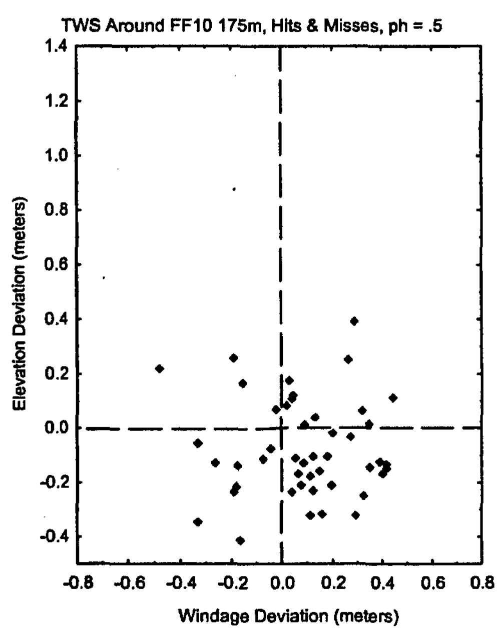
TWS Above

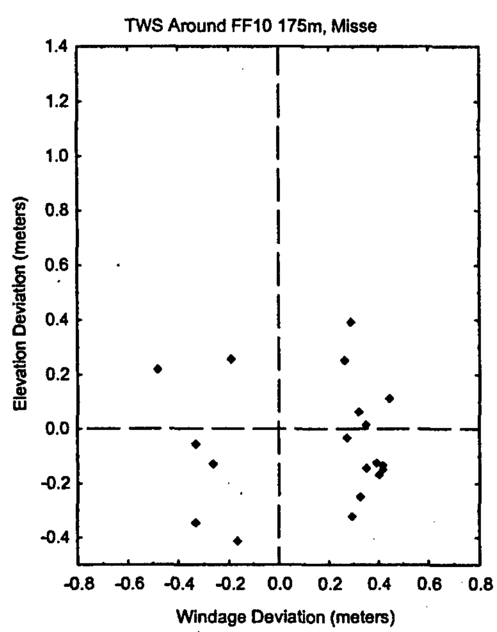


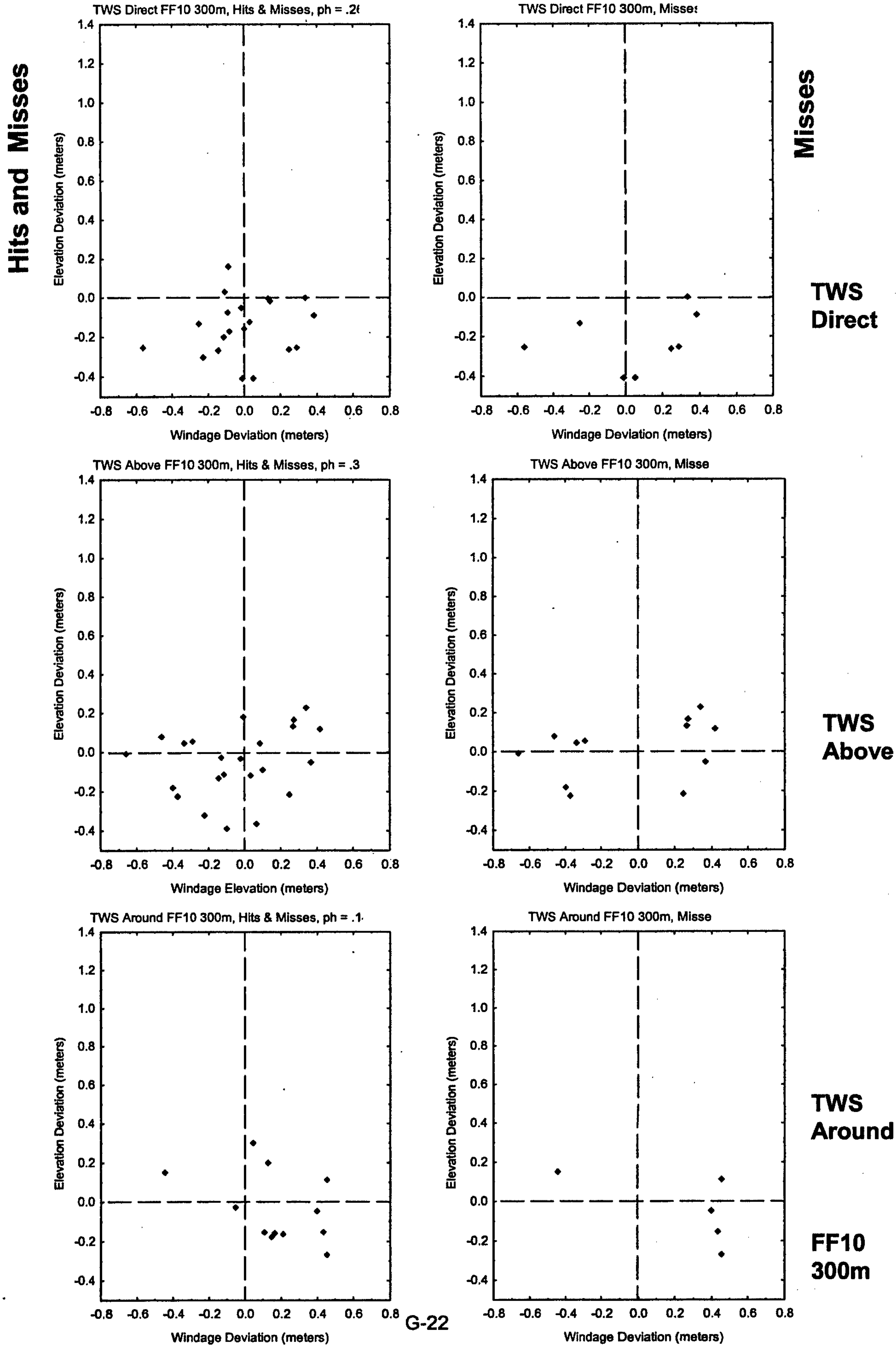


TWS Around

FF10 175m







Hits and Misses
Misses
TWS Direct FF10 300m, Hits & Misses, ph = .2(
TWS Direct FF10 300m, Misse:
TWS Direct
TWS Above FF10 300m, Hits & Misses, ph = .3
TWS Above FF10 300m, Misse
TWS Above
TWS Around FF10 300m, Hits & Misses, ph = .1·
TWS Around FF10 300m, Misse
TWS Around
FF10
300m
Elevation Deviation (meters)
Windage Deviation (meters)
Windage Elevation (meters)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.8
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8

Appendix H

Training Plan for Reduced Exposure Firing from Prepared and Hasty Positions

Purpose

The training plan provides recommendations for the training of skills, procedures, and techniques essential for Soldiers to acquire and engage targets employing reduced exposure firing using the Land Warrior (LW) system. This training and the associated training exercises are designed to reinforce existing skills, introduce and develop the required new skills, and develop a level of proficiency in reduced exposure firing techniques and skills. The concepts and exercises cited here reflect ideal training conditions to achieve a relatively high level of skill. The user may find that selected exercises and instruction from the guidance provided here best meet the Soldier's or the unit's training need.

Prerequisite Skills

Personnel receiving reduced exposure firing training must have the following skills.

- Can don/doff and assemble/disassemble the LW system, can correct malfunctions on the system, can use the Soldier interface to access the DVS and TWS images and to boresight the DVS using the DVS reticle screen, can change DVS fields of view.
- Can maintain and correct malfunctions on M16 series rifle/M4 carbine
- Are qualified on the M16 series rifle or M4 carbine
- Have advanced rifle marksmanship skills: burst firing, reflexive firing, night firing
- Can use a boresight kit to boresight the DVS and TWS
- Can maintain the DVS and TWS
- Can zero and operate the Thermal Weapon Sight (TWS)
- Can zero and operate the Daylight Video Sight (DVS)
- Possess target detection and identification skills with daylight optics such as the DVS and with thermal sights such as the TWS
- Can use a sling to engage targets

Reduced Exposure Firing Capabilities

The Land Warrior (LW) system is designed to provide enhanced lethality and survivability for the individual Soldier and the small Infantry unit. An aspect of this improved lethality and survivability is derived from the capability of the system to remotely display, at a relatively high frame rate, images acquired by weapon mounted daylight video sight (DVS) and thermal weapon sight (TWS) through the Soldier's helmet-mounted display (HMD). Both the DVS and the TWS can be employed to assist the Soldier with surveillance and target acquisition and as sight systems, to precisely align and aim the weapon for target engagement. Through the HMD, this remote view capability enables the Soldier to function in a manner similar to a submarine equipped with a periscope. While remaining almost fully concealed from enemy observation and/or presenting a small target for electro-optical detection and direct fires, the Soldier is able to acquire, detect, and effectively engage these targets to the maximum effective range of his weapon. The Soldier needs only expose the sighting system, DVS and/or TWS, weapon muzzle, and portion(s) of his body required to orient and provide stability to the weapon and the aligned sight systems. Collectively, the Soldiers of the small Infantry unit are able to reduce their vulnerability, providing targets that are difficult to detect and hit, and while simultaneously achieving an increased volume of aimed fires against enemy positions and formations (see Figure H-1).

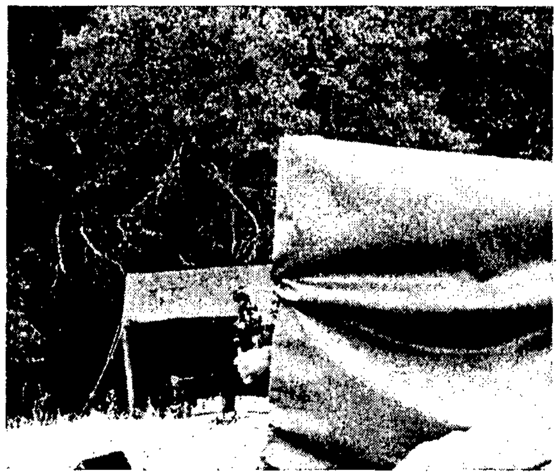


Figure H-1. Reduced exposure firer.

Exploiting Reduced Exposure Firing Capabilities

To fully exploit these new capabilities, the Soldier must employ previously trained and developed skills, as well as, new skills. Previously acquired individual movement, camouflage, position selection, marksmanship techniques and target detection skills are essential as foundation skills. Some skills, steady hold factors of rifle marksmanship for example, must be modified or adapted. The design of the Soldier's individual weapon is based on placement of the hands to support the weight of the weapon while aligning the weapon to the eye. This pointing alignment attains additional stability by being anchored in the pocket of the shoulder. The shoulder both assists as an anchor point for stability and by absorbing weapon recoil and permitting rapid reestablishment of stability for target assessment, reengagement, and/or reacquisition of the engaged or additional targets. With the Soldier now being able to orient the weapon/ sighting systems from a covered/concealed position in varied directions, new techniques, involving both foundation and new skills, must be developed. These new skills must be learned, integrated, and practiced to permit effective employment of these capabilities for surveillance, target acquisition, and fires in the reduced exposure mode.

Reduced Exposure Firing Skills

The critical skills involved from both defensive (prepared) and offensive (hasty) firing positions are listed below. The intent of the training guidance provided in this document is to enable Soldiers to acquire these skills.

The following skills are required to **acquire and engage targets from defensive (prepared) reduced exposure positions, above or around cover and concealment.**

- Prepare or assume a prepared fighting position that provides adequate cover and concealment and sectors of fire.
- Assume stable firing positions that take advantage of the prepared firing position's cover and concealment features.
- Assume firing positions that minimize muscle fatigue and provide stability for the weapon.
- Ensure firing positions do not obstruct the view of the optical device or field of fire for the weapon.
- Ensure firing positions allow the firer to scan the appropriate sector and then immediately engage targets within sector.
- Take procedures to reduce exposure to ejected hot brass (left-handed firers).
- Acquire and identify moving and stationary targets from defensive reduced exposure position during the day using the DVS and during the night using the TWS.
    - Select appropriate field of view (FOV) and switch FOV, as required, with the DVS and TWS for target engagement.
    - Use appropriate scanning techniques.
- Engage targets employing modified steady hold techniques.

The following skills are required to **acquire and engage targets from offensive (hasty, unprepared) reduced exposure positions, above or around cover and concealment.** There is overlap with the skills required for a prepared position, but the first two skills listed below stress some differences between two positions.

- Select a position quickly that provides cover and concealment and sector of fire in the assigned sector or in the direction of an approaching or potential enemy force.
- Assume stable firing positions, with or without the support of a sling, that take advantage of the cover and concealment and sector of fire.
- Adjust the hasty firing positions to minimize muscle fatigue and provide stability for the weapon.
- Ensure firing positions do not obstruct the view of the optical device or field of fire for the weapon.
- Ensure firing positions allow the firer to scan the appropriate sector and then immediately engage targets within sector.
- Take procedures to reduce exposure to ejected hot brass (left-handed firers).
- Acquire and identify moving and stationary targets from a hasty reduced exposure position during the day using the DVS and during the night using the TWS.
    - Select appropriate FOV and switch FOV, as required, with the DVS and TWS for target engagement.
    - Use appropriate scanning techniques.
- Engage targets employing modified steady hold techniques.

Firing Positions

There are two types of reduced exposure firing positions - the ***defensive (or deliberate) firing position*** and the ***offensive (or hasty) firing position***. A defensive firing position would be assumed from a prepared position like a foxhole or from behind a parapet. The offensive or hasty firing position would be used during movement. For example, the offensive position will permit the Soldier to safely scan and engage enemy forces from behind a tree stump, over a vehicle fender, or from the corner of a building after completing a three-to-five second rush to that location or from a temporary halt.

Each of these positions, in turn, has two firing techniques available to the firer. The firer can either fire ***above*** the cover and concealment by firing his weapon above his head and/or shoulder (an ***overhead*** position), or the firer may fire ***around*** the cover and concealment. Figure H-2 is an example of a firer engaging targets by firing with the weapon overhead. Figure H-3 is an example of a firer engaging enemy targets by firing around a parapet or obstacle providing cover. The choice of technique is situation dependent and up to the firer. As with traditional firing methods, the firer's stability and potential of enemy observation or intensity of enemy fires must be considered. The firer's stability is critical. The firer must consider which technique will minimize or prevent muscle fatigue and physical strain that may cause misaligned, hurried, and/or ineffective shots and a technique that best reduces his exposure to enemy observation and effective fires.

Figure H-2. Firing overhead.

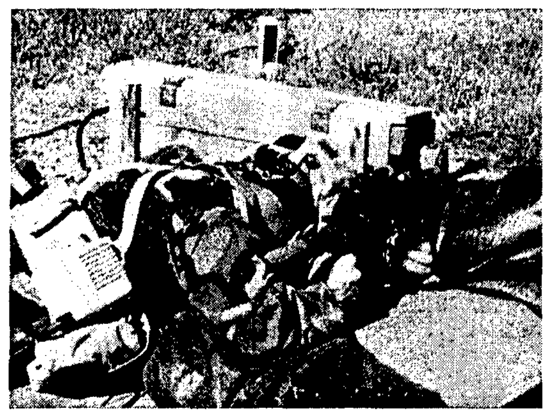


Figure H-3. Firing around cover.

Firing Position Teaching Points

Listed below are the primary considerations for the firing positions employing reduced exposure firing techniques. During training, each teaching point must be addressed. No one teaching point is more important than the others since all must be considered.

The firer must assume a position that provides adequate cover and concealment. The reduced exposure firing techniques minimize Soldier exposure to enemy observation and fires. Cover should be substantial enough to withstand incoming enemy fires, and concealment should be capable of reducing detection from aided observation and/or electronic detection.

The firer must be stable. The stability of the weapon and firer are critical. The firer must assume a position that will minimize or prevent muscle fatigue and physical strain that may cause hurried shots.

The cover and concealment must not obstruct the view of the optical device. Reduced exposure firing techniques require that the firer rely on an indirect view through his optical device. There must be a clear line-of-sight and unhindered field of fire with no or minimal obstructions between the area being scanned and the weapon optics.

Firers must consider the presence of hot brass being ejected in close-proximity to exposed skin. During traditional firing techniques, a left-handed firer would employ a brass deflector to canalize hot, spent cartages away from his body and prevent burns from the hot brass. Reduced exposure firing techniques place the weapon either above the head and body of the firer or beside the firer. Left-handed firers are most vulnerable. However due to variations in positions, all firers must be prepared to deal with hot brass being ejected in close proximity to the exposed skin of the face, neck, or forearms, depending on the firing position assumed.

Weapon Stabilization

Whether using traditional firing techniques or reduced exposure techniques, weapon stabilization is critical to successfully engaging enemy targets. Weapon stabilization while in a reduced exposure firing position will be a challenge for most firers. The firer will most likely not be able to maintain the steady-hold factors associated with the traditional firing techniques. The Soldier will not have a good cheek-to-stock weld with his weapon. The butt stock will most likely not be in the pocket of his firing shoulder. The firer's firing hand may not be able to grip and support the firing mechanism in the traditional manner or his non-firing hand may not be able to grip or support the front hand guards. Breath control techniques and trigger squeeze may be executed in a non-traditional manner. The bottom line is that the firer must stabilize the weapon through alternative means if he wants to hit or suppress the target.

Weapon Stabilization Teaching Points

As with the traditional firing techniques, principles of stability remain constant and there are several good firing positions that may be assumed when firing with the reduced exposure technique. The following principles must be considered if accurate firing is to be achieved.

The weapon's butt stock must be stabilized. Weapon recoil can throw off the sight picture. The rear of the weapon must rest on or against a stable area of the body. The butt stock of the weapon must be controlled and recoil accommodated. Depending on the firer's positions, techniques include using a portion of the body such as the bicep of the firing arm, shoulder blade and deltoid, and/or adjusting the sling to accommodate a secure weapon. In a prepared position, some firers have brought the firing knee forward to support the butt stock when lying on their non-firing side. Care must be taken to avoid an unnatural alignment of the weapon and avoid permitting stability of the butt stock to contribute to cant of the weapon.

The front of the weapon must be stabilized. As with the weapon butt stock, the front of the weapon must be stable. Techniques include using the non-firing hand to grip the peg grip or hand guards, forcing the upper barrel assembly against the cover or permitting it to rest with stability. Cant must be avoided and the essential sight alignment over the axis of the barreling must be maintained. Another technique is to adjust the weapon sling to position the weapon's upper receiver group tightly against the cover or as a support to the non-firing arm or hand providing stability to the weapon and to assist with attaining a good sight picture.

Figure H-4. Examples of unstable positions (butt stock not stabilized; front of weapon not stabilized). [These Soldiers will have difficulty engaging a target, and maintaining an accurate scan of the sector.]

Figure H-5. Examples of stable positions.

The weapon must be able to move to allow scanning. The weapon stabilizing technique must not interfere with the ability to move the weapon to scan the field of fire. The firer must position himself so that the weapon is stable, yet free to traverse the field-of-fire.

Trigger control must be maintained to prevent loss of a stable sight picture during firing. As with traditional firing positions, smooth execution of trigger pull is essential to maintaining sight alignment to hit the desired point of aim. While some reduced exposure positions generally maintain the linear stability of traditional positions, other reduced exposure positions may not permit the trigger to be actuated naturally with the tip of the firing index finger. The trigger squeeze may be executed by an elevated hand or with the thumb. Trigger squeeze must be executed by a stable squeeze motion, avoiding jerking the trigger and loss of sight alignment.

The Overhead Firing Position

In Figure H-6, the firer has assumed an overhead firing position. The weapon butt stock is supported by the meaty part of the firing shoulder with the firer pulling the weapon butt stock tightly into the shoulder. The weapon's front hand guards are resting on cover. The Soldier will move his non-firing hand to the peg grip on the upper receiver group. Once the Soldier grabs the peg grip, he will pull the weapon down and into his body to hold the weapon secure. This motion forces the weapon's upper receiver group snuggly against the cover (in this case, sand bags), securing a stable upper receiver group. With the weapon butt stock placed into the upper portion of the firing shoulder, the Soldier moves his firing hand and firmly grips the weapon's pistol grip. He again pulls the weapon down and into his shoulder. This action helps secure the rear of the weapon into his shoulder. The placement of both hands ensures a tight body-to-weapon firing position. Note that the firer is holding the weapon parallel to the ground with no obstacles obscuring the weapon's optical line-of-sight.

Figure H-6. Overhead firing position.

The Around Cover Obstacle Firing Position

In Figure H-7, the firer has assumed an around-cover firing position. The Soldier places the weapon butt stock into the firing arm bicep muscle and positions the weapon to the left or right of the cover. The Soldier will move his non-firing hand to the peg grip on the upper receiver group. Once the Soldier grabs the peg grip, he will pull the weapon down and into his body to hold the weapon secure. Ideally, there is an object such as a sandbag, tree limb, or stump from which to support the upper receiver group. If not, the Soldier may have to adjust his non-firing shoulder and elbow to attain a tight body position. With the

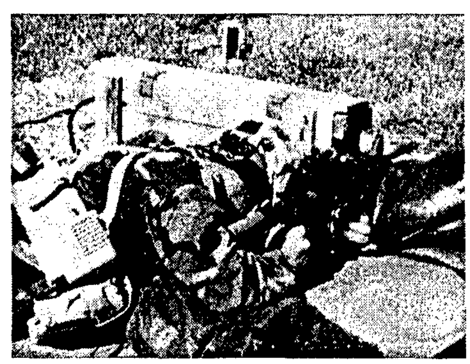


Figure H-7. Around cover firing position weapon butt stock placed into the non-firing arm bicep, the Soldier moves his firing hand and firmly grasps the weapon's pistol grip. Firmly grasping the weapon's pistol grip, the Soldier again pulls the weapon down and into his bicep. This action helps secure the rear of the weapon into firing position. The placement of both hands ensures a tight body-to-weapon firing position. Note that the firer is holding the weapon parallel to the ground with no obstacles obscuring the weapon's optical line-of-sight.

Use of a Sling to Stabilize the Weapon

The weapon's sling can be an effective tool to help stabilize the weapon. One common technique is to adjust the sling to permit the firer to bridge the sling around the forearm of his non-firing arm with the sling taunt across the back and shoulder blade or across the upper arm. This technique helps stabilize the barrel. This technique is taught to U.S. Army snipers. Unfortunately, the standard sling is too short to use the technique discussed in the following paragraphs.

Another option is to locally purchase a commercial off-the-shelf (COT) sling. There are several COT slings that can be purchased to improve weapon stabilization. Using the sling assists the firer in maintaining a tight weapon-to-body firing position. Figure H-8 shows an example of a commercially purchased hands-free sling. The sling is adjusted so that the firer's head and upper torso, including the firing arm and firing shoulder, fit through the bottom portion of the sling. The elbow is used as a fulcrum and becomes the apex of a stable triangle for support. The elbow is wedged between the body and sling to secure the weapon's butt stock into position. The firer's non-firing arm is then wrapped in the top portion of the sling by twisting the sling around the upper forearm. The firer then adjusts the sling placement by again using the elbow as a fulcrum. The firer pulls the weapon down until a tight body-weapon position is attained. The process is the same if the firer is in the overhead firing position. The firer adjusts his sling, using his elbows to adjust the sling position. In both firing positions, the firer then pulls the weapon down into the cover and into his body until a stable body-weapon position is attained.

Figure H-8. Use of a sling.

Scanning

Most weapon optics have a limited field of view (FOV). The view is somewhat like looking at an object through a paper towel roll. This requires the firer to move the weapon to scan entire the sector. Both the DVS and the TWS have a variable FOV. The widest view should be used when initially scanning the sector of fire. When a suspected target is located, the firer then adjusts the optic to the narrowest FOV for target identification and engagement. It should be noted that the WFOV more restricted than using the human eye. Thus training on scanning skills is critical.

The Soldier must find an easily identifiable focal point that can easily be hone in on. Because of the reduced peripheral vision caused by the optic, the firer should begin the scan at that recognizable object within the sector so he doesn't become disoriented. The focal point must be close in to the firing position. The focal point can be a large, odd-shaped or exposed rock, a large tree, or some other readily identifiable object. From that focal point, sector scanning should begin near the firing position moving left-to-right or right-to-left and progressively moving further away from the firing position with each scan (see Figure H-9).

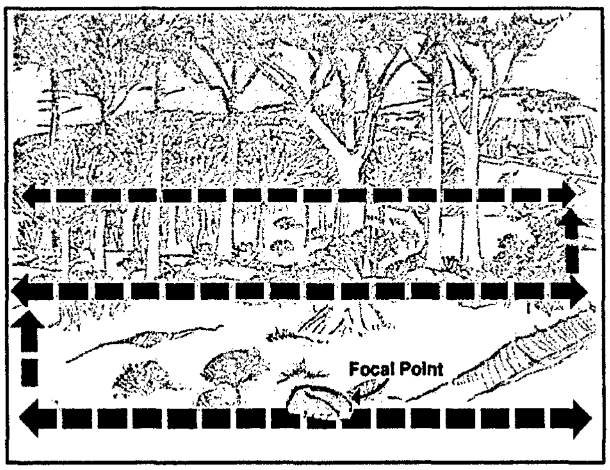


Figure H-9. Scanning Technique.

Scanning Teaching Points

There are several key points to remember about scanning techniques:

The optical sight (DVS or TWS) will cause the Soldier to lose peripheral vision. When looking through the optical sight, the FOV is limited to the sight picture. All peripheral vision is lost.

When using the optical sight, scan the terrain in the widest FOV available, then identify and engage target in narrowest FOV. If the optical device has a variable FOV, always scan in the widest FOV available to improve visibility within the sector. Motion can be detected much easier in a wide FOV. Once a suspected target is identified, begin adjusting to a narrower FOV to clearly identify the target. Always engage the target in the narrowest FOV. Scanning may be conducted in a narrow field of view, decreasing target identification times, by assigning Soldiers narrow sectors to scan. This technique is best accomplished when probable avenues of approach are identified or the direction of the enemy's approach is known.

The weapon must be able to move smoothly. The weapon must move freely in order to facilitate a rapid, yet smooth operation. There should also be minimal obstructions within the line of sight of the weapon and area to be scanned. The offset of the sight above the axis of the barrel must be considered. Objects may be in the clear view of the sight; however, the weapon muzzle may be obstructed by an obstacle (tree limb, dirt pile, etc.) that would deflect the bullet. Scanning below the intended line of sight or a quick scan over the cover and concealment may be required to confirm a clear field of scan and field of fire.

Start at a close recognizable object and scan outward. Find an easily identifiable focal point close in. That will help you retain your reference point. Then scan the sector, moving from left-to-right or right-to-left, gradually increasing the range of your sight picture throughout the sector.

Minimize weapon movement when switching FOVs. The designs of the DVS and TWS equipment impact how difficult it is to smoothly transition from one FOV to another. It is essential that the Soldier develop a technique that allows a smooth transition so he does not lose sight of the target while changing the FOV, and thus valuable time, in the acquisition process.

Conduct of Reduced Exposure Firing Training

The training exercises described here include dry-fire, MILES and live-fire. In their entirety, they cover the required reduced exposure firing skills listed at the first of this training plan.

1. ***Introductory Training Exercises.*** Soldiers, having qualified with their individual weapon using the steady hold factors, will find reduced exposure techniques alien. The Soldier should work on establishing a stable, defensive firing position first, for both around and over cover positions. Although an instructor can demonstrate various firing positions, each individual must ultimately determine what works best for his physique and firing preferences. Some coaching may be required for those with minimal marksmanship experience.

The concept of weapon stabilization remains the same. But as stated, no single way will work for all situations. The front and butt stock must be stabilized to maintain sight/optic alignment with the target. Weapon recoil must be controlled. A weapon sling regardless of type (standard, hands-free, one-point) can be used to assist in weapon stabilization. The Soldier must be instructed in the principles of stability with the sling. However, each Soldier must determine how to use the sling to best stabilize the weapon depending on reduced exposure firing position and technique used.

Once the Soldier has found a stable position(s), he should begin to work on scanning. There is no change to the current method used to scan a sector. However, scanning with optics must be done at a slower rate with deliberate movements to compensate for a "slower than the eye" frame rate. Because optics have less peripheral view/vision than the human eye, more consecutive overlapping scans are required to completely scan a sector. When scanning with an optic, the widest field of view should be used to acquire the target, with the firer changing to a narrower field of view for target identification and engagement.

In order to scan smoothly and still maintain a stable position, Soldiers should be trained to scan using a variety of techniques (over, around left side/right side) and body positions (left/right side, back, or stomach) using dry fire from behind or around fabricated sandbag cover position, walls, and trees. The use of the sling as a stability aid, both during movement and upon assumption of hasty (unprepared) positions, may be introduced as hand-eye coordination and stability in prepared reduced exposure positions are achieved.

Soldiers should be directed to scan areas from prepared and hasty positions with multiple targets (manmade or natural) at varied ranges (50m, 175m, 300m) in a narrow sector (15 to 20 degrees). Identification of targets can be incorporated into the introductory exercises. Standard dime/washer techniques can be used to verify stability of the weapon and trigger control as the targets are engaged. Training should emphasize weapon stability and minimizing exposure to the enemy. These introductory exercises can be done on a firing range or in a training area. Materials that provide cover are required.

2. ***Initial Skills PE #1 – Dry-fire target acquisition exercise (defensive/prepared positions)***. The intent of this exercise is to develop basic scanning skills from reduced exposure firing positions.

Training is conducted at a scanning range (20-meter separation between personnel, 300-meters deep) where individual Soldiers scan a 30-degree sector of fire using a reduced exposure firing technique (above or around cover) from a prepared position. Each sector of fire will have 16 computerized thermal targets scattered throughout the sector with two targets each at 50m, 75m, 100m, 150m, 175m, 200m, 250m, and 300m. Target scenarios will require two targets appear at staggered distances (for example 50m right side of sector and 175m left side of sector) for 20 seconds. Scanners will scan in the WFOV to locate the target, switch to the NFOV, simulate target engagement by lazing the target and report to the coach/instructor the distance to target. This ensures that the scanner located the proper target within his sector. He returns to the WFOV and continues scanning. Target exposure times could change as the scenario progresses. Soldiers repeat the scenario until 80% of the exposed targets (13 of 16) within the sector are identified.

After the Soldier has met the standard with a reduced exposure firing technique of his choice (above or around), Soldiers rotate; the scanner becomes the coach and the coach becomes the scanner. The training continues with a different target scenario (order of target exposures are different) until the standard is met with all Soldiers.

Examples of two scanning scenarios are shown in Table H-1 below. Scenario B is the more challenging and difficult of the two, as the acquisition times are shorter. Scenario B could be used later in training after Soldiers have had more experience with reduced exposure firing and as a check on skill progression.

Table H-1
Two Examples of Target Acquisition Scenarios (defensive prepared positions)

Scenario A			Scenario B		
Left Side	Right Side	Exposure	Left side	Right Side	Exposure
175m	50m	20 sec	175m	50m	15 sec
100m	150m	20 sec	100m	150m	10 sec
75m	300m	20 sec	75m	300m	11 sec
200m	250m	20 sec	200m	250m	9 sec
300m	75m	15 sec	300m	75m	10 sec
50m	200m	15 sec	50m	200m	15 sec
150m	175m	15 sec	150m	175m	10 sec
250m	100m	15 sec	250m	100m	9 sec

The leadership must insure that the coaches only record the scanner's target distances and do not "coach" the scanners as to target locations. The coach should also check to ensure that the scanner develops the skill to switch easily from the WFOV to the NFOV.

Training is conducted during daylight with the DVS and during reduced visibility/darkness with the TWS. Training standards are the same for the DVS and TWS. Soldiers must meet the standard for a single reduced exposure firing technique for each optic.

3. ***Initial Skills PE #2 – LIve-fire known distance target engagement exercise (defensive/prepared positions).*** The purpose of this exercise is to reinforce the requirements for a stable reduced exposure firing position, and to establish Soldier confidence in his ability to hit targets from a prepared, reduced exposure position. Soldiers can use his preferred posture (above or around cover; foxhole or prone position). Targets will stay up while the Soldier fires, thus eliminating the need to scan quickly to find the target. This is best conducted on location of miss and hit range (LOMAH) where precision in firing can be assessed, and the coach can diagnose firer weaknesses. The LOMAH system immediately displays the locations of both hits and misses, which provides essential feedback on the firer's point of aim and stability. A traditional known distance range could be used, but would provide less feedback to the firer and the coach. The range must be thermal capable for the TWS firing. Coaches should ensure that the firer minimizes his exposure to the enemy.

At a minimum, Soldiers should fire at a close target (50 to 100m), an intermediate target (150 to 200m) and a far target (250 to 300m). Exact distances depend on the capabilities of the ranges that are available. A minimum of 5 rounds should be fired at each distance, with an overall standard of 80% hits. For purposes of safety, there should be one or two lanes between firers. The known distance exercise also provides the opportunity for trainers to alert firers to be prepared to deal with hot brass ejected from their weapon.

Training will be completed during daylight with the DVS and during darkness/limited visibility with the TWS. Although the technique of fire is the same with both sights, it is important for Soldiers to obtain feedback on the linkage between their sight picture and round location when firing with each sight, as the target signature with the TWS differs significantly from that with the DVS day optic.

4. ***Intermediate Skills PE # 1- Scan individual sector and engage an opposing force as a member of a squad/platoon (MILES exercise).*** This exercise is the first of several which require integration of reduced exposure firing skills. MILES is used to conserve ammunition and also to provide a more realistic target environment than that on a firing range.

Firers, organized as a unit, are provided a scenario indicating the approach of a larger enemy force. Squad/platoon leadership emplaces the personnel in a linear ambush in a sparsely wooded area in accordance with ARTEP 7-5. Soldiers are directed to assume stable hasty positions employing the sling to enhance stability. Soldiers are equipped with MILES and assigned a 30-degree sector of fire. The reduced exposure firing position used (above or around) will depend on available cover from the Soldiers' particular assigned fighting position.

The opposing force (OPFOR) equipped with MILES will move through the kill zone. (Number of OPFOR will depend on size of unit being trained.) The unit must initiate the ambush when the majority of the enemy is in the kill zone. Evaluators will observe unit actions; pass/fail grade will be in accordance with ARTEP 7-5 standards. The OPFOR should approach the kill zone from both directions and meet at the center of the kill zone. This allows for both flank securities to scan and report enemy movement. Upon initiation, two or more OPFOR should flee the kill zone along the routes entered allowing flank securities the opportunity for target engagement.

Evaluators should observe and conduct an after action review at completion of each exercise. Training will be completed during daylight with the DVS and during darkness/limited visibility with the TWS.

5. ***Intermediate Skills PE #2 - Move under enemy fire using reduced exposure firing techniques (MILES).*** The firers, organized as a unit (squad or platoon) are provided a scenario indicating that a small enemy force has been detected in the area. The enemy is expected to attempt to avoid contact and flee if detected. The squad/platoon is equipped with MILES and moving through a sparsely wooded area. The unit is engaged by enemy direct fire from a far ambush or sniper. The initial fires against the unit should not produce casualties but provide a signature to locate the enemy. The unit takes cover and is directed to locate and assault enemy position in accordance with ARTEP 7-5. The unit should move by fire team and personnel should move by individual movement techniques. Sparse cover and OPFOR direct fire will necessitate personnel to use reduced exposure firing techniques in combination with direct observation and engagement techniques for locating, suppressing, and eliminating the enemy. Soldiers should scan in the WFOV and engage in the NFOV.

Evaluators should observe and conduct an after action review at completion of each exercise. Training will be completed during daylight with DVS and during darkness with TWS.

6. ***Advanced Skills PE: Live-fire from prepared positions using reduced exposure techniques.*** The firers, organized as a squad, are provided a scenario to defend in sector. Enemy attack from a specified direction (down range) is imminent. Unit will defend by squads. Personnel should fire on every other lane of a standard Field Fire range from prepared (with sandbags) positions. If the range has 18 lanes then the squad would fire on lanes 1, 3, 5, 7, 9, 11, 13, 15, and 17). If the range has 27 lanes every third lane would be used 1, 4, 7, 10, etc. This will reduce the number of cross lane fires, add validity to computer scoring, and is recommended for purposes of safety.

Personnel may fire from the foxhole or prone position using either the above or around reduced exposure firing technique. The firer's direct view of the target area will be obscured and only the weapon and non-firing hand, if required, may be exposed to detection or engagement from the down range, target area. Weapon slings may be used to assist with weapon stabilization. Soldiers should initiate scanning in the WFOV and may engage targets in the NFOV. However, once firing has commenced the field of view will be the option of the Soldier.

The range must be thermal capable for TWS night firing. Target exposure times could be lengthened to 10 seconds per single target exposure and 20 seconds for multiple (2) target exposures. The same target scenario will be used for DVS daylight firing and TWS night firing. Firers must hit 13 of 22 targets (80%) to receive a GO for both day and night firing with extended exposure times (see Scenario A in Table H-2). A more challenging scenario is illustrated with Scenario B, where a more realistic standard for Soldiers conducting this exercise the first time would be 60-70%.

Table H-2
Live-fire Field Fire Scenarios

Scenario A **Field Fire w/ Extended Exposure Times** 22 targets		**Scenario B** **Field Fire w/ Standard Exposure Times** **22 targets**	
Target Sequence	Exposure time (sec)	Target Sequence	Exposure time (sec)
175m	10	175m	8
75m, 300m	20	75m, 300m	11
75m, 175m	20	75m, 175m	11
300m	10	300m	8
75m, 175m	20	75m, 175m	11
175m, 300	20	175m, 300	11
75m, 175m,	20	75m, 175m,	11
175m, 300m	20	175m, 300m	11
75m	10	75m	8
175m, 300m	20	175m, 300m	11
75m, 175m	20	75m, 175m	11
75m, 300m	20	75m, 300m	11
175m	10	175m	8

Safety

Common to all live-fire training, and in particular, reduced exposure firing, is safety. Since the reduced exposure firing technique differs significantly from that of traditional firing techniques and the fields of view through the optical devices limit visibility, additional safety requirements are necessary. The following are common safety practices that should be considered when conducting reduced exposure firing training:

- Soldiers should receive reduced exposure firing training outdoors where they can physically manipulate the weapons and optical devices, view targets at various ranges through the LW indirect view capability (helmet mounted display) while employing various cover obstacles, and receive training on the prone, kneeling-supported, and standing-supported reduced exposure firing positions. This training or refresher training should be conducted in immediate conjunction with any live-fire training.

- Post safety and live-fire training regulations must be reviewed as part of the range planning sequence. Training time can significantly differ based on local post requirements. For example, some posts require a walk-through of the exercise, followed by a dry-fire and then a blank-fire prior to executing a live-fire exercise.
- Before conducting reduced exposure live-fire training, post range safety personnel should be contacted and briefed on the planned firing to identify any additional safety requirements necessitated by that post.

Conclusion

In reduced exposure firing, the principles of marksmanship have not changed. However, the methods of applying them have. Remembering the few "must dos" will improve target selection and engagement, and just may save Soldiers' lives.

Appendix I
Acronyms

ANOVA	Analysis of variance
CCO	Close combat optic
DVS	Daylight video sight
FF	Field Fire
FOV	Field of view
FPE	Firing point equipment
HMD	Helmet mounted display
JCF AWE	Joint Contingency Force Advanced Warfighting Experiment
KD	Known distance
LOMAH	Location of misses and hits
LW	Land Warrior
MOS	Military occupational specialty
NCO	Noncommissioned officer
NFOV	Narrow field of view
OCS	Officer Candidate School
Ph	Probability of hit
PM-LW	Project Manager-Land Warrior
RMD	Radial miss distance
SCU	Soldier control unit
TSM-S	TRADOC Systems Manager-Soldier
TWS	Thermal weapon sight
USAIS	United States Army Infantry School
WFOV	Wide field of view
WUID	Weapon user interface device